Report on the FM ILT PhFPU functional tests

Marc Sauvage,

with numerous inputs from

Olivier Boulade,
Eric Doumayrou,
Jérôme Martignac,
Thomas Müller,
and Louis Rodriguez

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1 Reference Documents

RD1	SAp-PACS-MS-0616-06	PACS FM Photometer Focal Plane Unit User's Manual
RD2	SAp-PACS-MS-0247-04	PACS CQM Photometer Focal Plane Unit User's Manual

2 Purpose of this document

As a series of roughly identical functional tests of the PhFPU will be performed through the course of the FM ILT, it is probably a good idea to hold in a single document all the results and analyses of these tests. Part, or the totality of this document will also find its place in the final PACS FM test report.

Table 1 identifies the different tests analyzed in this report by their date of occurence. For those tests performed with the PACS warm electronics, the reference of the telemetry filename is also given. The temperature level at which the tests were performed is indicated. The status column indicates the processing status for the test data, and "OK" is the label of successful functional tests.

Table 1: References for the functional test. In the status column I give some indication of the test results. "OK" is for successful tests. "Commanding" implies some inconsistencies between the commanded biases and the housekeepings, "Signal" means the signal behavior is not what we expect, and "Noise" means the noise behavior is not what we expect. In all these cases, more details can be found in the respective sections of this report.

Test Date	Electronics set-up	Temperature	filename	Status
17/07/2006	LTU+BOLC QM1	Warm	private telemetry format	Commanding, Signal, Noise
24/08/2006	LTU+BOLC QM1	Warm	private telemetry format	Commanding, Signal, Noise
11/10/2006	LTU+BOLC FM	Warm	private telemetry format	OK
31/10/2006	LTU+BOLC FM	4 K	private telemetry format	OK

The rest of this document is a test-by-test report on each functional test. As the purpose of the test is to first check that the instrument is functional and second to check that it has remained unchanged since the last occurence of the test, it is impossible to avoid a certain feeling of "déjà vu" (all over again, as our english-speaking friends would add for some obscure reason) while reading the report.

3 The warm functional tests of 17/07/2006

3.1 Test description

These tests were performed at the end of the integration at Keyser-Threde. The instrument was warm, and though the PhFPU was in its FM version, a QM version of the warm electronics was used, namely BOLC QM1. This BOLC version commands only two groups (see RD1 for a description of the PhFPU warm electronics). Because of this the test script is repeated three times, and each time the harnesses between BOLC and the PhFPU are moved so that all 6 groups of the PhFPU can be explored. Because of BOLC QM1, the test script used is different from that described in RD1. The `VH_BLIND` levels were lower to avoid saturation on BOLC QM1 and no group-per-group `VRL` scales

were performed as this made little sense when only two groups could be tested at a time. Finally one has to remember that because BOLC QM1 can only control two groups, one has to change the wiring between BOLC and the PhFPU to change the groups that are switched on, but as far as BOLC is concerned, no change has occured. Therefore in all the tests, we always see the same two groups switched on (#1 and #3) and we always get data at the same location of the telemetry.

The actual execution of the test that day was the following:

- The first test has BOLC connected to matrices M1, M2, M3 and M4 (i.e. the actual groups 1 and 2). This is test #1 of this section. Telemetry files for this test have a date between `19:33:56` and `19:35:38`.
- The harnesses are reconnected so as to now see matrices M5, M6, M7, and M8 (i.e. the actual groups 3 and 4). Remember that M8 is the matrix with a missing readout channel. This is test #2 of this section. Telemetry files for this test have a date between `19:48:07` and `19:49:49`.
- The harnesses are reconnected so as to now see matrices M9 and M10, the read matrices (i.e. groups 5 and 6). This is test #3 of this section. Telemetry files for this test have a date between `20:01:48` and `20:03:30`.

Before moving on to the analysis, I simply recall that judging from the logbook notes of that test, everything appeared to proceed correctly.

3.2 Analysis

Because the test was performed with a private equipment, it was also analyzed with a private system, called PIRE, which is inherited from the CAM interactive analysis and thus is in IDL. An important aspect is the conversion of the HK information from decimal to analog values. As the test was performed with BOLC QM1, I have used a conversion file called `Tm_hk_QM1.txt`. Usinq QM1 conversion factors actually required some slight modifications of PIRE to make it more flexible in its handling of the multiple BOLC versions[1].

The analysis performed is rather straightforward: first we inspect the biases time sequence to check that the bias commands are correctly executed, then we turn to the pixel signal to check that we observe the expected variations.

3.2.1 Bias commands execution

The first step here is to check the value of `GND-BU` as this value will be present in all the BU HKs and thus we need to add it to all the BU commands to check whether the command matches the HK. Remember that this bias is either on or off, i.e. one does not command its value, it has to be read in the HK themselves, and there is one value per group. In the current test `GND-BU` is around 0.46 V (see table 2 for the actual median value of `GND-BU`). Note that the rms of `GND-BU` during a test is typically around 1-2 mV.

There are a large number of biases that can be set in each group, but for the purpose of this test, we can restrict our inspection to the biases that see their state change during the test. This give a total of 18 biases that I have grouped into 3 sets. The first set contains the biases that, at some point in

[1] As of 03/10/06, these have now been integrated in the reference version of PIRE.

Table 2: The value of GND-BU measured during the three tests. The units are Volts

17/07/2006					
Test #1		Test #1		Test #1	
Group 1	Group 3	Group 1	Group 3	Group 1	Group 3
0.463	0.462	0.463	0.462	0.463	0.463

the test, generate the signal changes, the second set contains the biases that need to be modified so that the signal changes are visible, and the last set contains similar biases but that are commanded only once during the test. I do not show here the biases that are never commended (and hence set at 0 V by the `reset all bias` command at the start of the test procedure) or commanded to be at 0 V during the script. In fact only two biases are in that category: VCH and VSMS-H. I have however checked that they are indeed at 0 V during the whole test.

The first set of biases contains VH_BLIND, VDD, VRL, VH, and VL. Remember that VDD is a BU bias hence the comparison between the HK and commanded value has to take into account GND-BU. The time sequence of commands to these biases, as well as the corresponding HK values, is given in table 3 as well as displayed graphically on figure 1. There is not significant differences in the housekeeping data for this set of biases between the three tests, therefore only the data for test #1 are displayed.

As can be seen from table 3 and figure 1, the test appears to proceed quite correctly. Everything is nominal on group 3, while VDD does not reach the commanded values on group 1, sometimes by 40 mV. We will come back to that later (I have considered that differences between the commanded and HK value of less than 20 mV are no cause for alarm).

The second set of biases contains VGG, VDECX-H, VDECX-L, CKRLL, CKRLH. Remember that VGG is a BU bias. Table 4 gives the timeline of the commands to these biases as well as the value read in the HK. This timeline is graphically displayed on figure 2.

This time the discrepancies are minor and affect only VGG a BU bias, on group 1 again. Interestingly, VGG is not incorrect when it is set to 0 V, we will come back to that later.

The final set of biases contains those that are set only once, i.e. VGL-BU, VDL-BU, VSS-BU, VGL, VDL, VSS, VSMS-L, VINJ. For those biases I list in table 5 their commanded values and the measured HK values. For this set, it is rather straightforward to indentify the BU biases. Note that this is not a time-ordered table. As with the first two sets of biases, the differences in the HK between the three tests are not significant.

Here again, there are some discrepant values (mostly for group 1).

In conclusion of this exploration of the bias commanding during the test, we see that almost all of the biases reach their correct commanded value. **However out of the total of 82 commanded biases, we have 5 major discrepancies (by 40 mV or more) and 7 minor ones (by 20 mV or more). All these discrepancies occur on group 1.**

The first explanation that comes to mind is that this is related to the use of the "all groups" commanding method in the test script. As this uses average conversion factors, this will necessarily lead to errors at the individual group level. However these errors are too small to explain what we see here.

Another possibility is that something is wrong either in the analog to digital conversion of the commands or in the digital to analog conversion of the housekeepings. Regarding the digital to analog conversion of the HK I have tried using the FM conversion coefficients but this did not solve the

Table 3: Bias commanding checks for the 5 most important biases of the test. This is a time-ordered table though the timing of the commands is not indicated. The status column is decided upon the match quality between the commanded and the HK value. A checkmark indicates that the command is correctly executed, a question mark that some discussion is required, and a double question mark that an investigation is required. Units in the table are Volts. For the BU biases, I indicate both the commanded value and that value corrected by `GND-BU` level in parenthesis. This table contains the time sequence for test #1.

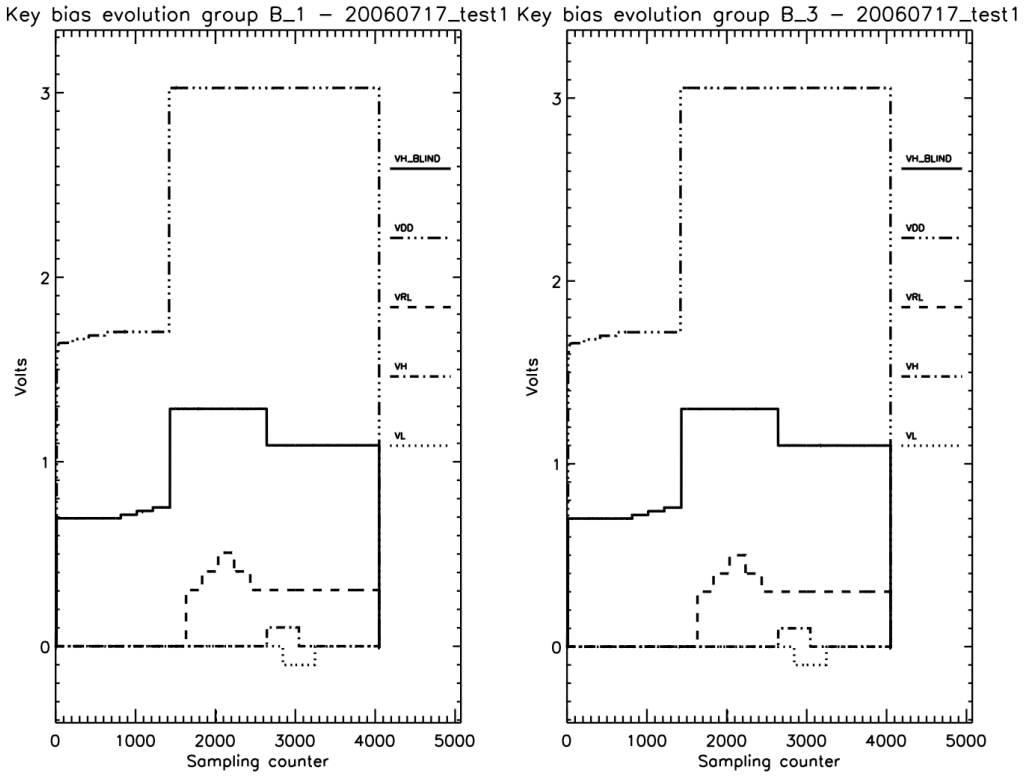
17/07/2006								
Bias setting values					Group 1		Group 3	
VH_BLIND	VDD	VRL	VH	VL	Value	Status	Value	Status
0.70					0.69	√	0.70	√
	1.20 (1.66)				1.64	?	1.66	√
	1.22 (1.68)				1.66	?	1.68	√
	1.24 (1.70)				1.68	?	1.70	√
	1.26 (1.72)				1.70	?	1.72	√
0.72					0.71	√	0.72	√
0.74					0.73	√	0.74	√
0.76					0.75	√	0.76	√
	2.60 (3.06)				3.02	??	3.06	√
1.30					1.29	√	1.30	√
		0.30			0.31	√	0.30	√
		0.40			0.41	√	0.40	√
		0.50			0.51	√	0.50	√
		0.40			0.41	√	0.40	√
		0.30			0.30	√	0.30	√
1.10					1.09	√	1.10	√
			0.10		0.10	√	0.10	√
				−0.1	−0.10	√	−0.10	√
			0.00		0.00	√	0.00	√
				0.00	0.00	√	0.00	√

problem. I cannot however exclude that the file called `Tm_hk_QM1.txt` that resides in PIRE is not the correct file to use for BOLC QM1.

On the other hand, since I have the LTU logfile I can make a check of the analog to digital conversion. First, I have inspected the logfile and converted again almost all the analog values to their hexadecimal codes using the FM tables. This reveals that **almost all the conversions where indeed done with FM tables**. This is likely the reason for most of the discrepancies observed between the commanding and the HK, i.e. the conversion tables do not correspond to the hardware. This can indeed be verified using RD2 where the conversion coefficients for the commanding of BOLC QM1 are listed. For all the biases showing commanding/HK descrepancies of tables 7 to 9 I have converted back the digital command into an analog value. This shows indeed that **for all the discrepant biases, the digital command used corresponds to an analog command equal to what we find in the HK**. Therefore we can conclude that **all the discrepancies observed here are due to the use of incorrect commanding conversion tables**.

This analysis also revealed two intriguing facts: first the `VH_BLIND` hexadecimal values are offset by 3 units from the expected values using FM conversion tables. Second the `VGG` command setting it to 0 V as the hexadecimal argument `0001`. Both the QM1 and FM conversion tables would give a negative

Figure 1: Time evolution for the 5 most important biases. Units on this figure are Volts. Note that to produce a clean figure, I have median-filtered the HK values. On the figure, I give the actual HK values, uncorrected for the GND-BU level. This figure shows test #1.



code for a command of 0 V so this is in fact a protective feature of the LTU software. This is why for that command we indeed get what we want (0001 is virtually indistinguishable from 0000, i.e. 0 V on VGG), while non-0 V commands on VGG reveal the commanding problem.

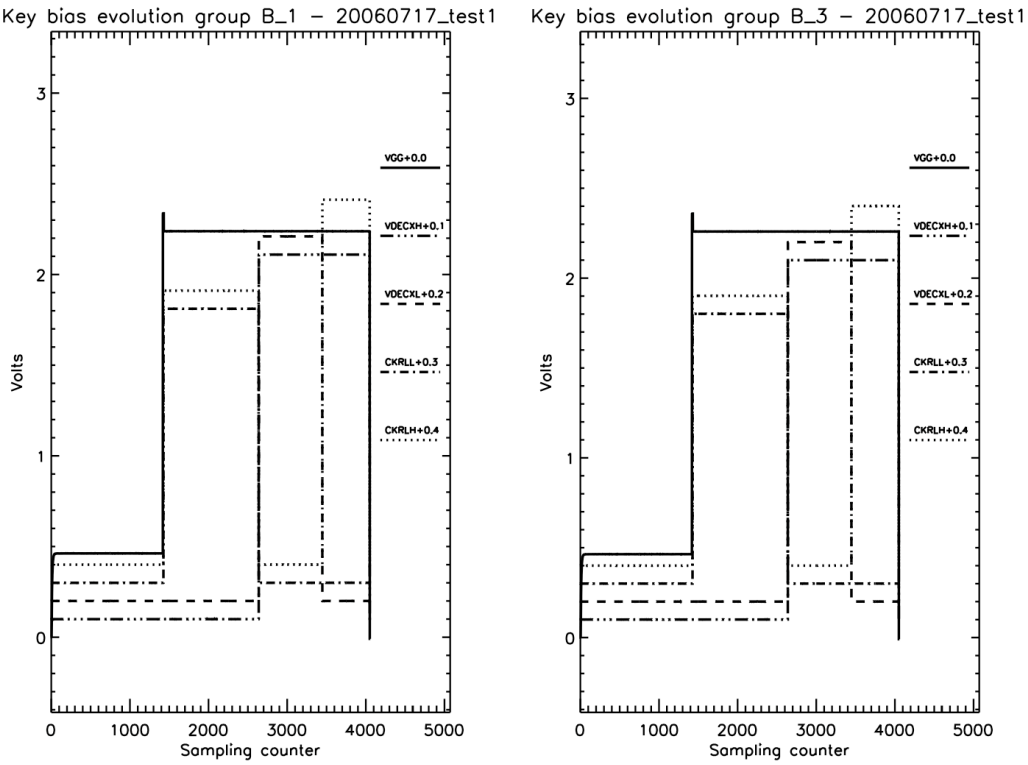
Table 4: Bias commanding checks for the second bias set of the test. This is a time-ordered table though the timing of the commands is not indicated. A checkmark in the status column indicates that the command is correctly executed. For the BU biases, I indicate both the commanded value and that value corrected by GND-BU level in parenthesis. Units in the table are Volts. This table contains the time sequence test #1.

17/07/2006								
Bias setting values					Group 1		Group 3	
VGG	VDECX-H	VDECX-L	CKRLL	CKRLH	Value	Status	Value	Status
0.0 (0.46)					0.46	√	0.46	√
1.9 (2.36)					2.34	?	2.36	√
	0.0				0.00	√	0.00	√
		0.0			0.00	√	0.00	√
				1.5	1.51	√	1.50	√
			1.5		1.51	√	1.50	√
1.8 (2.26)					2.24	?	2.26	√
				0.0	0.00	√	0.00	√
			0.0		0.00	√	0.00	√
	2.0				2.01	√	2.00	√
		2.0			2.01	√	2.00	√
		0.0			0.00	√	0.00	√
				2.0	2.01	√	2.00	√

Table 5: Bias commanding checks for the last set for biases. A checkmark in the status column indicates that the command is correctly executed. For the BU biases, I indicate both the commanded value and that value corrected by GND-BU level in parenthesis. Units in the table are Volts. This table contains the values observed during test #1

17/07/2006					
Bias name	Commanded values	Group 1		Group 3	
		Value	Status	Value	Status
VGL-BU	3.0 (3.46)	3.42	??	3.46	√
VDL-BU	4.2 (4.66)	4.60	??	4.65	√
VSS-BU	1.0 (1.46)	1.45	√	1.46	√
VGL	3.0	3.02	?	3.00	√
VDL	3.0	3.04	??	3.00	√
VSS	0.7	0.70	√	0.70	√
VSMS-L	3.0	3.01	√	3.00	√
VINJ	3.0	3.04	??	3.00	√

Figure 2: Time evolution for the second set of biases. Units on this figure are Volts. Note that to produce a clean figure, I have median-filtered the HK values. On the figure, I give the actual HK values, uncorrected for the GND-BU level. This figure shows test #1.



3.2.2 Signal analysis

We now turn to the data part of the telemetry. As explained in the test description, we expect to have in test #1 and #2 data at the telemetry location of M1, M2, M5 and M6, while for test #3 we expect to have data only at the telemetry location of M1 and M5. This is indeed the case and thus it is a relief[2].

The complete sequence: The analysis of the signal is straightforward. Since the signal is completely generated by the bias commands (i.e. none is due to the sensitive part of the bolometer), we only need to check one pixel per readout channel, i.e. 16 pixels per matrix. Because PIRE is a homemade IDL package, it is not completely straightforward to know which index of the arrays corresponds to the channel. To circumvent this, I have extracted the signal on pixels (i, i), with i from 0 to 15. I plot the timeline of each of these pixels and compare it to the reference one shown in RD1. All these timelines (160 in total) are shown in figure 3.

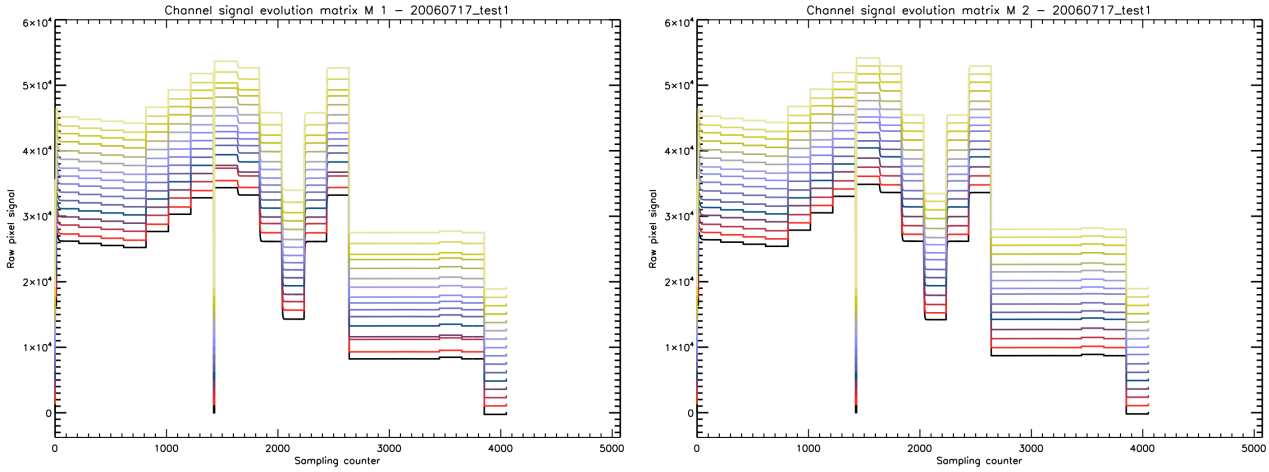


Figure 3: Signal timeline for the 16 channels of matrices M1 and M2 in test #1. These are two blue matrices. Note that each timeline is artificially offset from the previous one for clarity. The first 4 downward steps correspond to the `VDD` sequence. The following 3 upward steps correspond to the `VH_BLIND` scale. They are followed by another upward step corresponding to the setting of `VH_BLIND` before the `VRL` scale. This `VRL` scale is the symetric 5-steps sequence. Then we have a long plateau that corresponds to the `VH-VL` sequence, invisible with this dynamical range (but see figure 4), followed by the sequence of readout modes **Sbolo_only**, **Sref_only** and **Sbolo−Sref**. For this last sequence we observe a clear difference with the reference sequence of RD1: the signal in the **Sbolo_only** is higher that in **Sref_only** here while the opposite is true in RD1. See the text for a discussion of this discrepancy.

Each of the channels displayed on figure 3 except one[3] shows a similar pattern, which is a first good sign. This pattern is almost identical to that of RD1: the first 4 downward steps correspond to the `VDD` sequence. The following 3 upward steps correspond to the `VH_BLIND` scale. They are followed by another upward step corresponding to the setting of `VH_BLIND` before the `VRL` scale. This `VRL` scale is the symetric 5-steps sequence. Then we have a long plateau that corresponds to the `VH-VL` sequence,

[2]Remember also that PIRE is in IDL and thus the index of M1 is 0...

[3]This is the absent channel of matrix M8, so this is expected and part of the "success" criteria for the functional test.

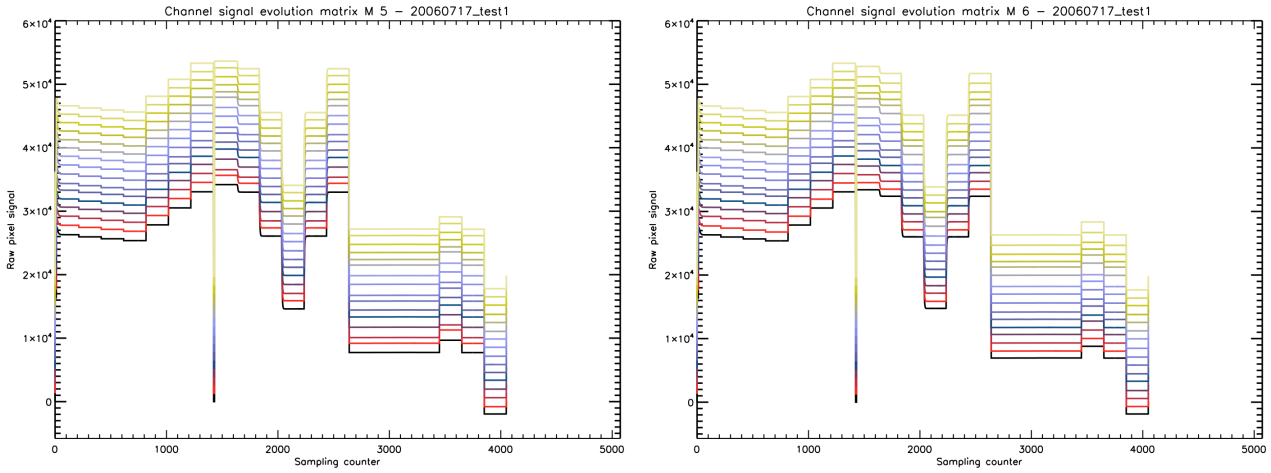

Channel signal evolution matrix M 5 – 20060717_test1
Channel signal evolution matrix M 6 – 20060717_test1
Raw pixel signal
Sampling counter

Figure 3: Continued. Signal timeline for the 16 channels of matrices M5 and M6 in test #1. These are blue matrices.

invisible when the full dynamical range is used (see later), followed by the sequence of readout modes **Sbolo_only**, **Sref_only** and **Sbolo−Sref**. **It is for this last sequence that we observe a clear difference with the reference sequence of RD1**: the signal in the **Sbolo_only** is higher that in **Sref_only** here while the opposite is true in RD1.

The reason for this difference is not straightforward: it cannot be the different `VH_BLIND` levels used for this run, as the `VH_BLIND` differenciation is performed whatever the readout mode (see RD1). It should therefore not affect the relative positionning of the **Sbolo_only** and **Sref_only** signals. It is very unlikely that it is a result of the FM/QM1 commanding problem as this affects only group 1 biases yet both group 1 and group 3 signals show the same behavior.

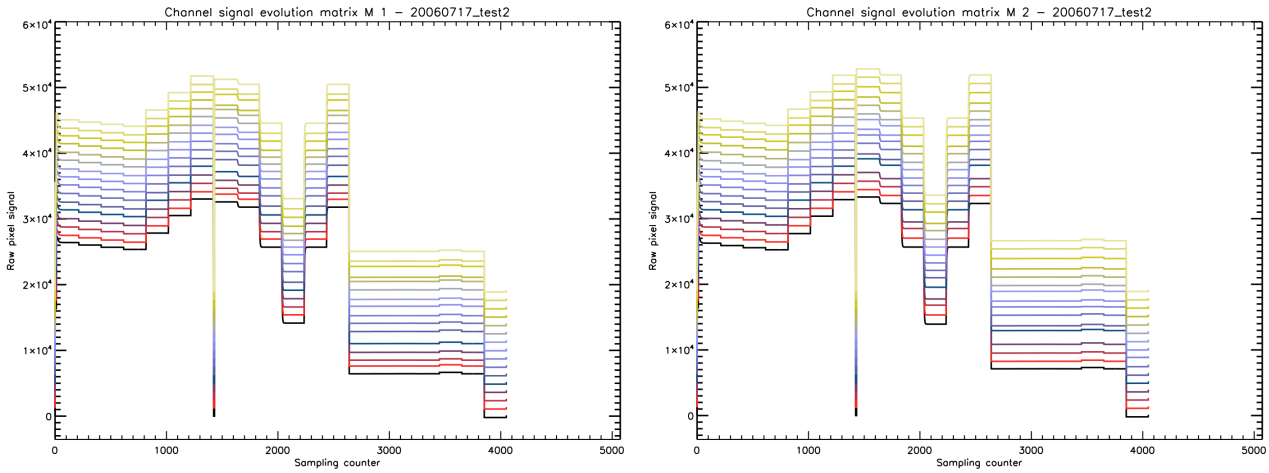

Channel signal evolution matrix M 1 – 20060717_test2
Channel signal evolution matrix M 2 – 20060717_test2
Row pixel signal
Sampling counter

Figure 3: Continued. Signal timeline for the 16 channels of matrices M1 and M2 in test #2. These are blue matrices.

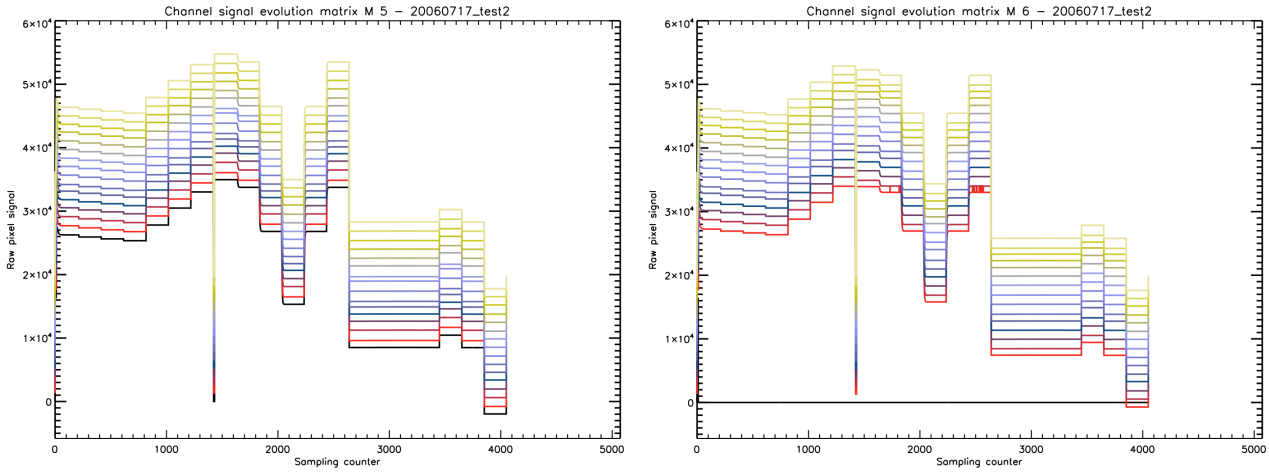

Channel signal evolution matrix M 5 – 20060717_test2
Channel signal evolution matrix M 6 – 20060717_test2
Row pixel signal
Sampling counter

Figure 3: Continued. Signal timeline for the 16 channels of matrices M5 and M6 in test #2. These are blue matrices. In fact, M6 is really M8 of the PhFPU as can be seen from the missing channel.

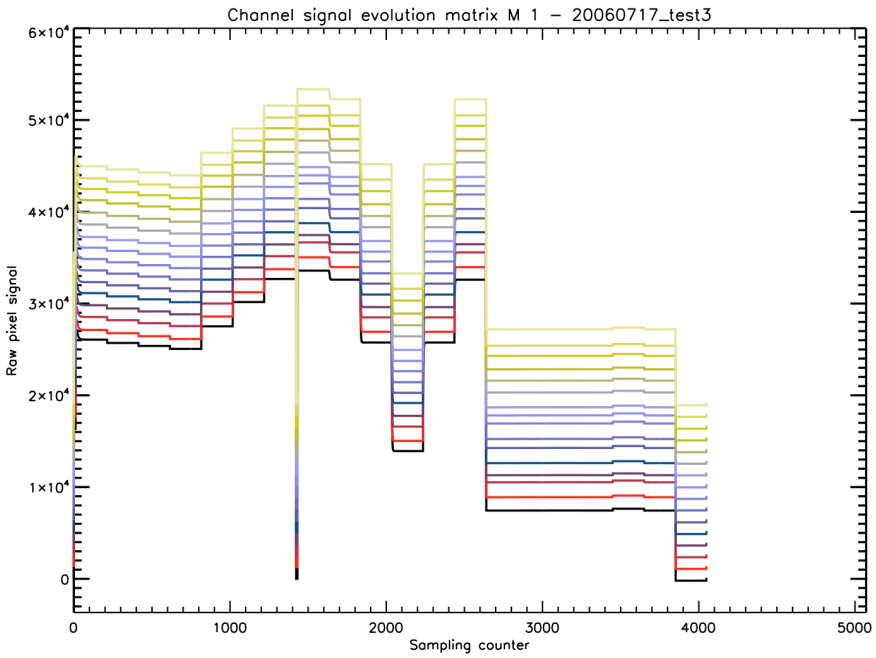


Figure 3: Continued. Signal timeline for the 16 channels of matrix M1 in test #3. This is a red matrix.

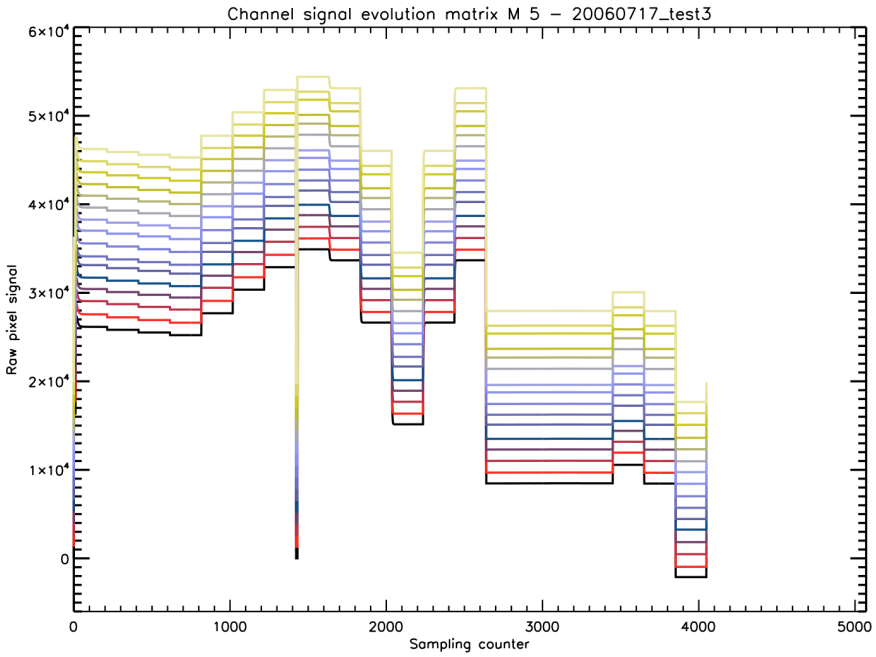


Figure 3: Continued. Signal timeline for the 16 channels of matrix M5 in test #3. This is a red matrix.

The VH-VL sequence: When the instrument is warm, it is extremely hard to see the effect of the VH-VL sequence (see appendix A) when the full dynamical range is used. It is in fact also hard to clearly identify on a pixel level (VH and VL are used to adjust the value of the mid-point voltage, but when the system is warm this is very inefficient). Thus I have instead build the average signal per matrix and this is what is displayed on figure 4, with the value of VH and VL superimposed.

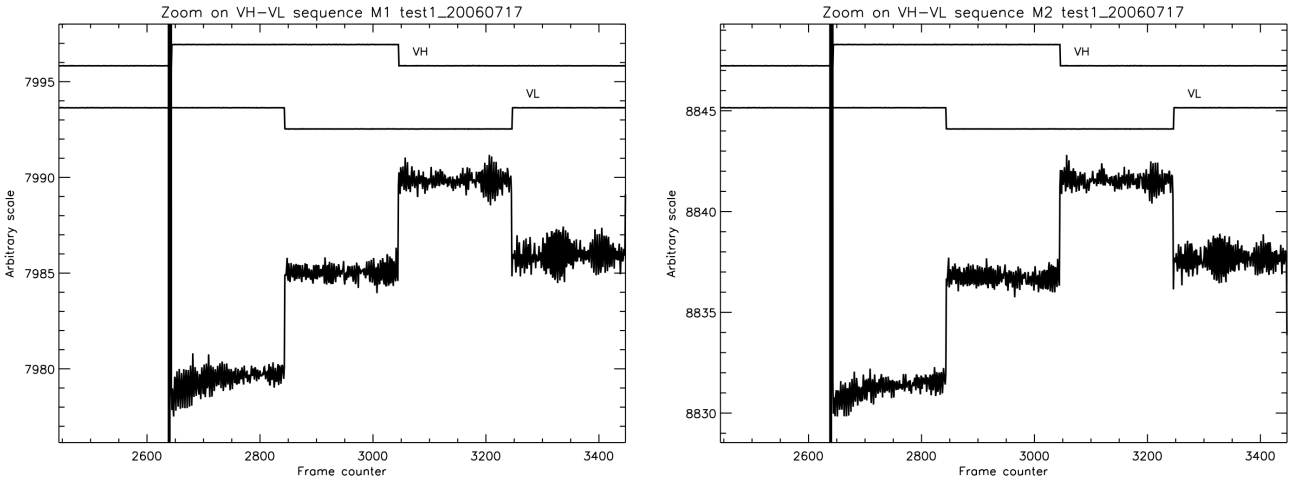


Figure 4: The VH-VL sequence as observed on the mean signal for matrices M1 and M2 during test #1. These are blue matrices. The effect of changing these biases is evident on the mean signal, while it is much more difficult to indentify at a pixel level. The transitory period that follows any bias change is most evident at the start of the sequence at this scale. Also evident is the presence of "non-white" noise on the data, that is clearly correlated between matrices (see text for analysis).

The first important point to stress is that the global behavior of the VH-VL sequence is in accordance with the expectations. Remember that we are during this part of the test in the mode **Sref_only**, i.e. that we are reading the bolometer "signal", or the midpoint bias level and that this signal is affected by a minus sign[4]. Therefore decreasing the midpoint level (by decreasing VH or VL) increases the signal level. Thus this part of the test sequence is successful. The second point is a little bit more worrying: during test #1, we observe the presence of a supplementary noise component that is correlated between matrices of a given group as well as between groups. To try and identify the origin of this noise component we have computed the power spectrum of the signal during the VH-VL sequence. This is in fact not a simple task as this sequence is not meant to compute power spectrum, i.e. the plateaus are rather short (about 200 readouts each), thus the resulting power spectrum is itself not well sampled. Therefore I had to separate the VH-VL sequence into four parts, corresponding to the 4 different settings of the (VH,VL) pair. For each sequence I have performed of power spectrum calculation. Figure 5 shows on of these power spectra, here obtained from the second part of the VH-VL sequence for (VH,VL) at (0.1, −0.1) on matrix M2 during test #1. This figure nicely shows a rather typical situation for test #1: the power spectra show a rather strong component at 10 Hz. For some sequences, the peak is smaller and wider but this is likely due to the small number of samples (200) used to compute the power spectrum.

This is a situation that has occured before at SAp and corresponds to the pick-up of the general 50 Hz frequency of the lab's power supply though various channels that are not (or sometimes cannot be) completely shielded. This origin can help understand why this noise component is quite correlated

[4]Those who are lost now should check back into RD1.

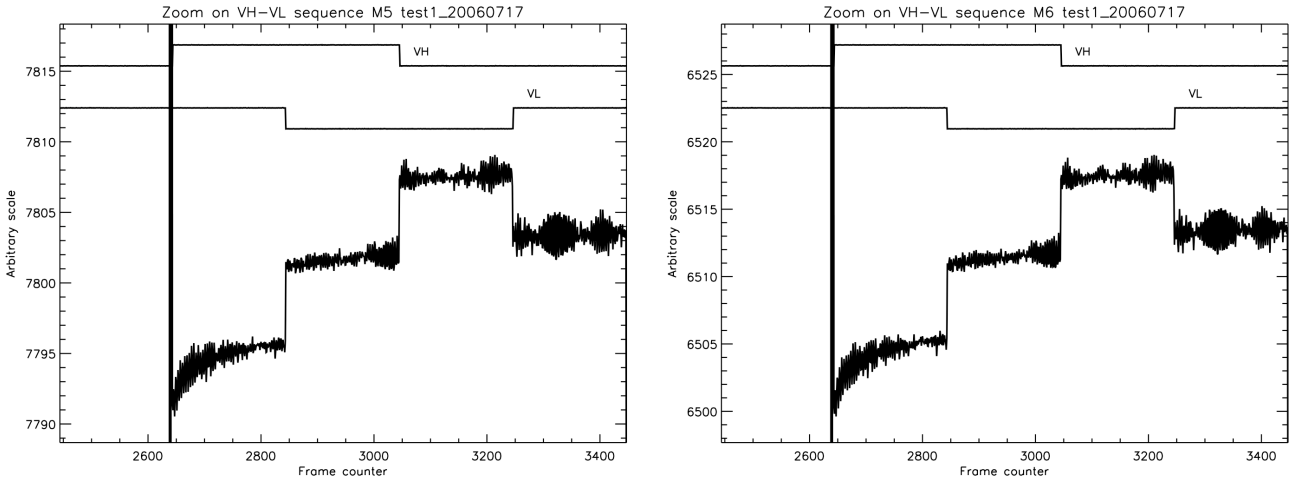


Figure 4: Continued, this time for matrices M5 and M6 during test #1. As can be seen the "non-white" noise component is also correlated between groups.

between matrices and groups during a given test. Its physical origin is probably related to the fact that the test equipment used here does not guarantee a complete shielding of the PhFPU-BOLC system. The QM harnesses used to connect BOLC QM1 need special adapters to connect to the FM PhFPU and these break the shielding continuity. When the complete FM instrument is assembled, the PhFPU and BOLC will be completely shielded.

I have performed the same exercice for test #2, where figure 4 seems to indicate that this noise component is absent. This reveals that we in fact still pick up the 10 Hz noise component, but at a much fainter level (the peak's height is generally a factor 3 to 10 times smaller). If one wants to be optimistic, this variation in the amplitude of the 10 Hz component can be seen as a confirmation that it is indeed due to noise pick-up through the BOLC-PhFPU connection harnesses, are these are disconnected and reconnected between tests.

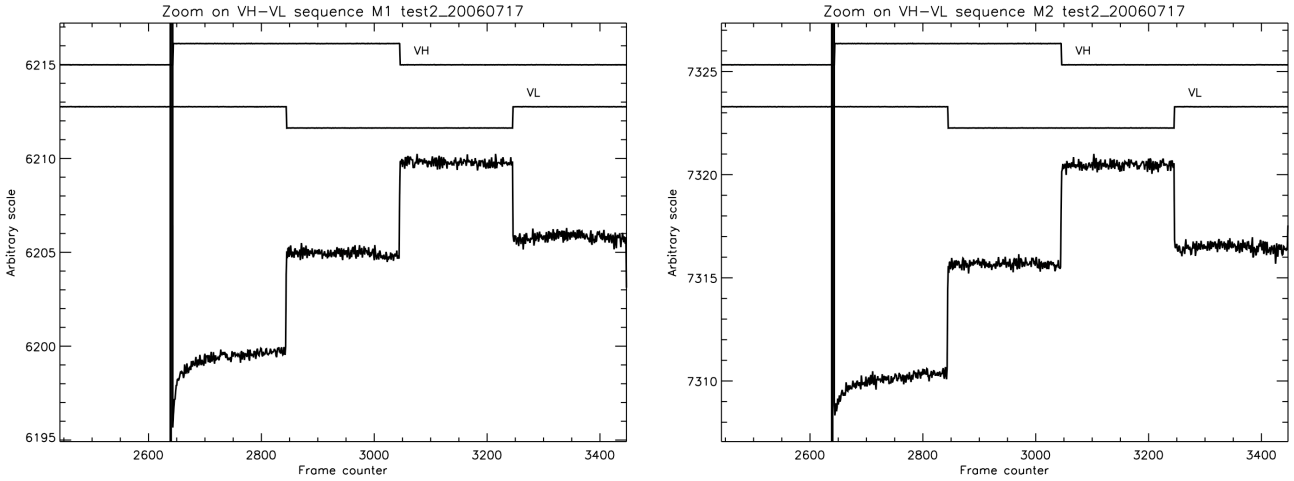


Figure 4: Continued, this time for matrices M1 and M2 during test #2. The "non-white" noise component is not present here so the transitory periods are much more evident.

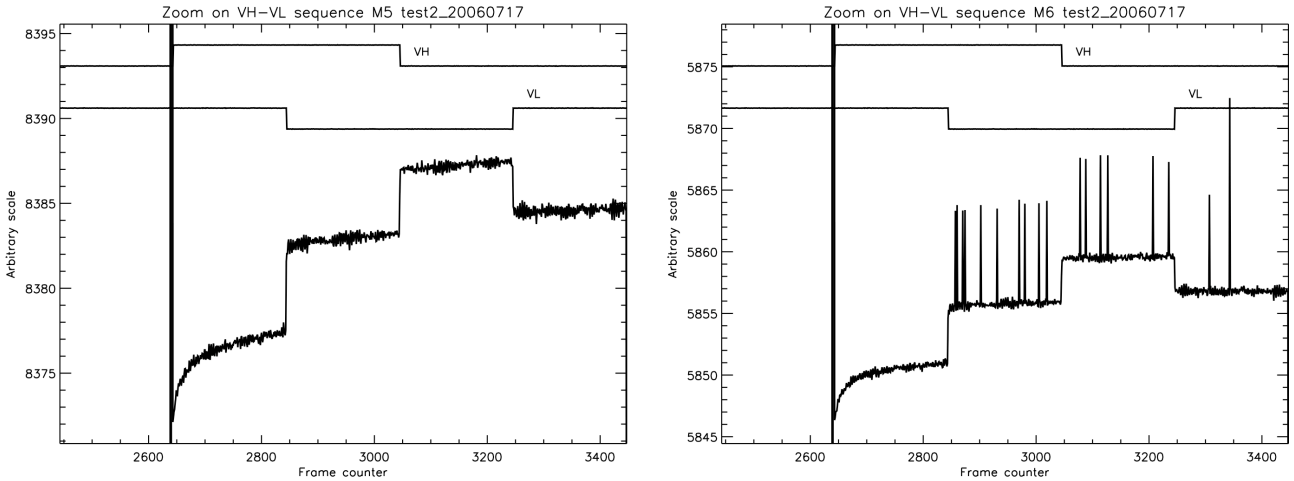


Figure 4: Continued, this time for matrices M5 and M6 during test #2. The "non-white" noise component is not present here so the transitory periods are much more evident. The data line shows quite a lot of spikes that were not present on figure 3. This is because here the signal was not median-filtered.

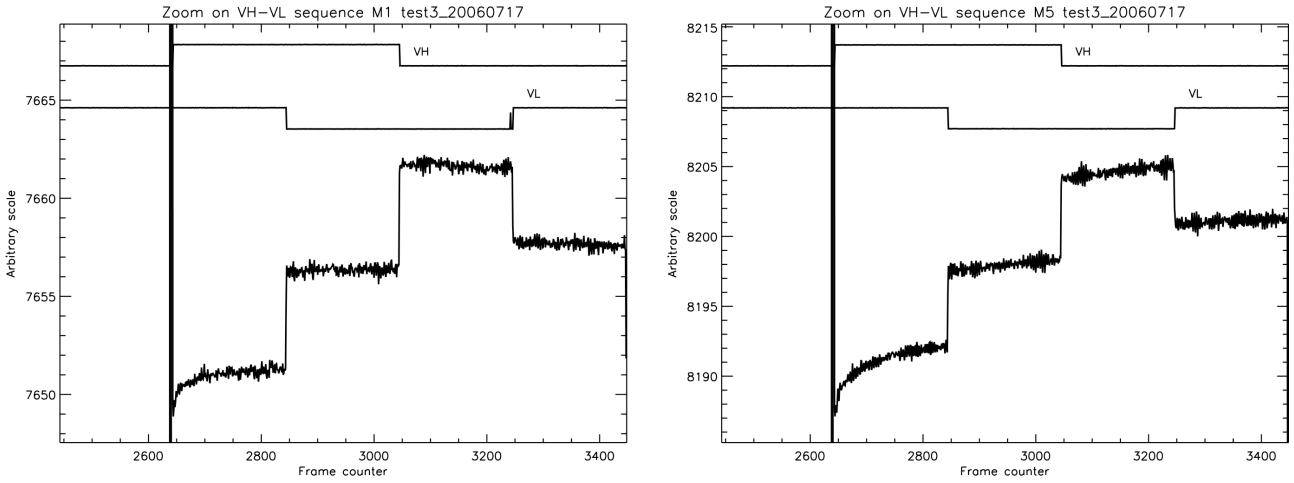


Figure 4: Continued, this time for matrices M1 and M5 during test #3. Contrary to the previous panels, as these are the two red matrices, the data are obtained from two different groups. The "non-white" noise component is not present here so the transitory periods are much more evident.

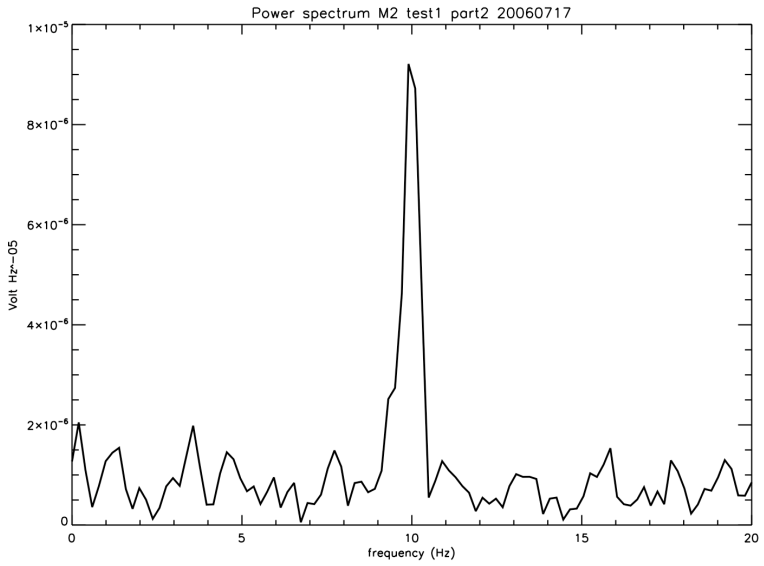


Figure 5: The power spectrum of the mean signal on matrix M2 observed during the second part of the VH-VL sequence (VH = 0.1, VL = −0.1) V of test #1.

3.3 Conclusions

The objective of this test is to check that all electrical lines to the bolometers are functionning. This objective is fully reached here. However it is worth mentioning that:

- One has to check that the commanding conversion tables correspond to the version of the BOLC hardware used.
- The relative level of the signal between the **Sref_only** and the **Sb_only** mode is different from that observed in SAp, and the origin of this is unknown.
- We pick up an extra noise component with a characteristic frequency of 10 Hz, which is likely due to the general lab power supply 50 Hz frequency and the lack of complete shielding between BOLC QM1 and the FM PhFPU. This shielding will be complete when BOLC FM is used.
- The current procedure is not adequate to quantify the noise on the signal (it was not meant to be). Since we do observe extra noise sources, it would be good to introduce a "waiting" plateau after the `VH-VL` sequence long enough to accumulate more than 200 samples on the signal.

4 The warm functional tests of 24/08/2006

4.1 Test description

These tests were performed at the end of the integration of the PhFPU at MPE. The instrument was obviously warm and since the FM warm electronics of PACS was not complete, we have used the SAp Local Test Unit (LTU) to perform the test. Another major difference in the setup is the use of the QM1 version of BOLC, rather than the FM version. This BOLC model can only control two groups, therefore a series of tests had to be performed to explore the behavior of all the groups of the PhFPU (see RD1 for a description of the PhFPU warm electronics). Also, because of BOLC QM1 peculiarities, some differences exist between the test script as described in RD1, and the actual test script used here: The `VH_BLIND` levels were lower to avoid saturation on BOLC QM1 and no group-per-group `VRL` scales were performed as this made little sense when only two groups could be tested at a time. Finally one has to remember that because BOLC QM1 can only control two groups, one has to change the wiring between BOLC and the PhFPU to change the groups that are switched on, but as far as BOLC is concerned, no change has occured. Therefore in all the tests, we always see the same two groups switched on (#1 and #3) and we always get data at the same location of the telemetry.

The actual test execution was as follows:

- A first run was performed with BOLC connected to groups 5 and 6 of the PhFPU, i.e. the two red matrices (M9 and M10). In this test, stops were placed at crucial points to allow visual checking of the test progress (mostly the execution of bias commands). This test was performed mostly to validate the test script in the present electronics configuration and is not analyzed here.
- This first test was repeated, without the stops. In this section this is going to be test #1.
- The wiring between BOLC and the PhFPU was changed so that BOLC was connected to groups 1 and 2, i.e. matrices M1, M2, M3, and M4, and the test script was repeated. In this section this is going to be test #2.

- The wiring between BOLC and the PhFPU was changed again so that BOLC was connected to groups 3 and 4, i.e. matrices M5, M6, M7, and M8. In this section this is going to be test #3.

Telemetry recording was started each time after the sequencer loading script, but with a variable delay before the start of the actual test scripts, therefore tests #1, #2 and #3 differ slightly in their initial sequence.

4.2 Analysis

Similarly to the 17/07/06 tests, these were analyzed with PIRE, with the conversion file called `Tm_hk_QM1.txt` to transform the HK into analog values.

The analysis performed is rather straightforward: first we inspect the biases time sequence to check that the bias commands are correctly executed, then we turn to the pixel signal to check that we observe the expected variations.

4.2.1 Bias commands execution

When performing this part of the analysis, remember that for all the BU biases one has to add the value of `GND-BU` to all the commanded values before comparing them to the HK values. In the current test, `GND-BU` is around 0.46 V (see table 6 for the actual median value of `GND-BU`). As can be seen from a comparison with table 2, changes of the order of 1 mV have occured. This is not significant.

Table 6: The median value of `GND-BU` measured during the three tests. The units are Volts

24/08/2006					
Test #1		Test #2		Test #3	
Group 1	Group 3	Group 1	Group 3	Group 1	Group 3
0.463	0.463	0.463	0.462	0.462	0.462

For the sake of clarity, I have grouped the biases in three sets.

The first set contains the biases that are extensively used in the test, either because we regularly need to tune the electronics with them or because we rely on these biases in the test. This group contains `VH_BLIND`, `VDD`, `VRL`, `VH`, and `VL`. Table 7 lists the time sequence of the commands to these biases as well as the status of the command deduced from the HK. Figure 6 shows graphically the time evolution of these biases. For this part of the test analysis, it turns out that the differences between the three tests are very small, so I have only displayed the information for test #1.

At this point, It appears that the test is proceeding nominally, apart from differences between the commanded and housekeeping values for group 1 (on `VDD` essentially). Interestingly, at the 10 mV accuracy, we observe no difference in the bias setting between this test and that of 17/07/06. Given that the test script is exactly the same, this is both expected and welcome.

In the second set of biases, I have placed biases which are set more than once during the script although they are not directly responsible for the signal variation in the test. They are adjusted so that we can see the signal variation. These biases are `VGG`, `VDECX-H`, `VDECX-L`, `CKRLL` and `CKRLH`. As for the first set of bias, I have placed in table 8 the time-ordered sequence of bias setting commands and their execution status. Figure 7 shows the graphical timeline of these biases. Since most of them have the same values, I have introduced artificial offsets so that the figure becomes clearer. Here again

Table 7: Bias commanding checks for the 5 most important biases of the test. This is a time-ordered table though the timing of the commands is not indicated. A checkmark in the status column indicates that the command is correctly executed, a question mark that some discussion is required, and a double question mark that an investigation is required. Units in the table are Volts. For the BU biases, I indicate both the commanded value and that value corrected by GND-BU level in parenthesis. This table contains the time sequence for test #1.

24/08/2006								
Bias setting values					Group 1		Group 3	
VH_BLIND	VDD	VRL	VH	VL	Value	Status	Value	Status
0.70					0.69	√	0.70	√
	1.20 (1.66)				1.64	?	1.66	√
	1.22 (1.68)				1.66	?	1.68	√
	1.24 (1.70)				1.68	?	1.70	√
	1.26 (1.72)				1.70	?	1.72	√
0.72					0.71	√	0.72	√
0.74					0.73	√	0.74	√
0.76					0.75	√	0.76	√
	2.60 (3.06)				3.02	??	3.06	√
1.30					1.29	√	1.30	√
		0.30			0.31	√	0.30	√
		0.40			0.41	√	0.40	√
		0.50			0.51	√	0.50	√
		0.40			0.41	√	0.40	√
		0.30			0.30	√	0.30	√
1.10					1.09	√	1.10	√
			0.10		0.10	√	0.10	√
				−0.1	−0.10	√	−0.10	√
			0.00		0.00	√	0.00	√
				0.00	0.00	√	0.00	√

the differences observed between the three tests are extremely small and for clarity I have only shown the information related to test #1.

For this second set of bias we observe again that the test appears to proceed quite nominally, except for some slightly discrepant values on VGG for group 1, Again a situation identical as that observed on 17/07/06.

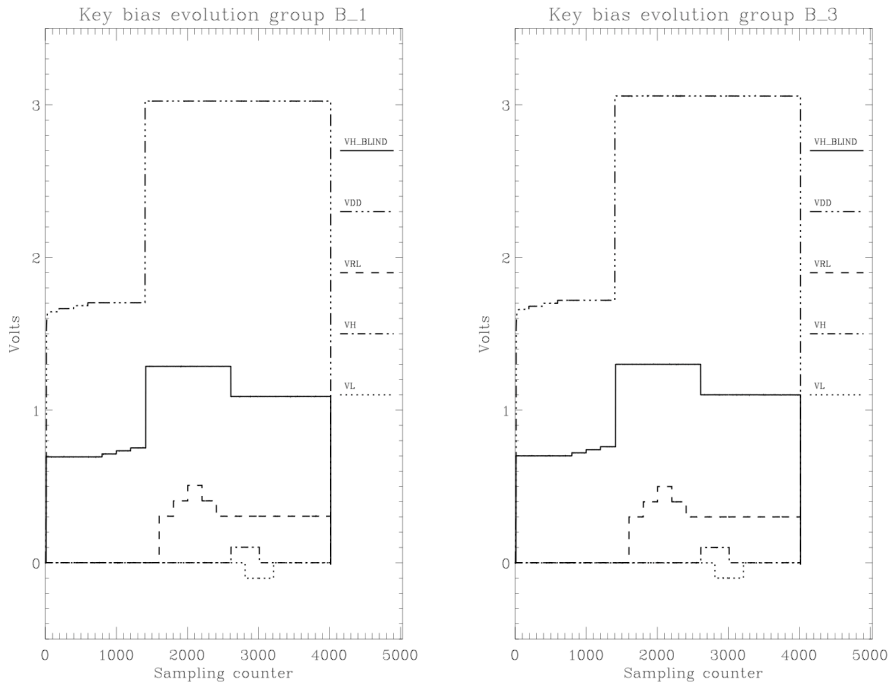
Thirdly there is a last set of biases that I've grouped together because they are only set once (I do not include biases that are set to 0 V. Those are commanded with the 0000 hexadecimal code which is always correct). This last set contains VGL-BU, VDL-BU, VSS-BU, VGL, VDL, VSS, VSMS-L, and VINJ. Table 9 compares the commanded values for these biases to the observed value. This table is not time-ordered as those biases are only set once during the test. Again no significant difference is observed between the three tests so only the information of test #1 is given.

Here again, there are some slightly discrepant values (mostly for group 1), exactly identical to those we found during the tests of 17/07/2006.

Finally the two remaining biases VCH, and VSMS-H that are supposed to remain at 0 V. I have checked that this is indeed the case during all three tests.

In conclusion of this exploration of the bias commanding during this test, we see that we are exactly in

Figure 6: Time evolution for the 5 most important biases. Units on this figure are Volts. Note that to produce a clean figure, I have median-filtered the HK values. On the figure, I give the actual HK values, uncorrected for the GND-BU level. This figure shows test #1.



the same situation as on 17/07/2006. Therefore we know that the reason for the bias command/HK discrepancies is the use of incorrect commanding tables. One should remark that the purpose of repeating these tests is to make sure nothing changes between each occurence of the test. As far as the biases are concerned, this is indeed the case and thus the test is successful.

Table 8: Bias commanding checks for the second bias set of the test. This is a time-ordered table though the timing of the commands is not indicated. A checkmark in the status column indicates that the command is correctly executed. For the BU biases, I indicate both the commanded value and that value corrected by GND-BU level in parenthesis. Units in the table are Volts. This table contains the time sequence test #1.

24/08/2006								
Bias setting values					Group 1		Group 3	
VGG	VDECX-H	VDECX-L	CKRLL	CKRLH	Value	Status	Value	Status
0.0 (0.46)					0.46	√	0.46	√
1.9 (2.36)					2.34	?	2.36	√
	0.0				0.00	√	0.00	√
		0.0			0.00	√	0.00	√
				1.5	1.51	√	1.50	√
			1.5		1.51	√	1.50	√
1.8 (2.26)					2.24	?	2.26	√
				0.0	0.00	√	0.00	√
			0.0		0.00	√	0.00	√
	2.0				2.01	√	2.00	√
		2.0			2.01	√	2.00	√
		0.0			0.00	√	0.00	√
				2.0	2.01	√	2.00	√

Figure 7: Time evolution for the second set of biases. Units on this figure are Volts. Note that to produce a clean figure, I have median-filtered the HK values. On the figure, I give the actual HK values, uncorrected for the GND-BU level. This figure shows test #1.

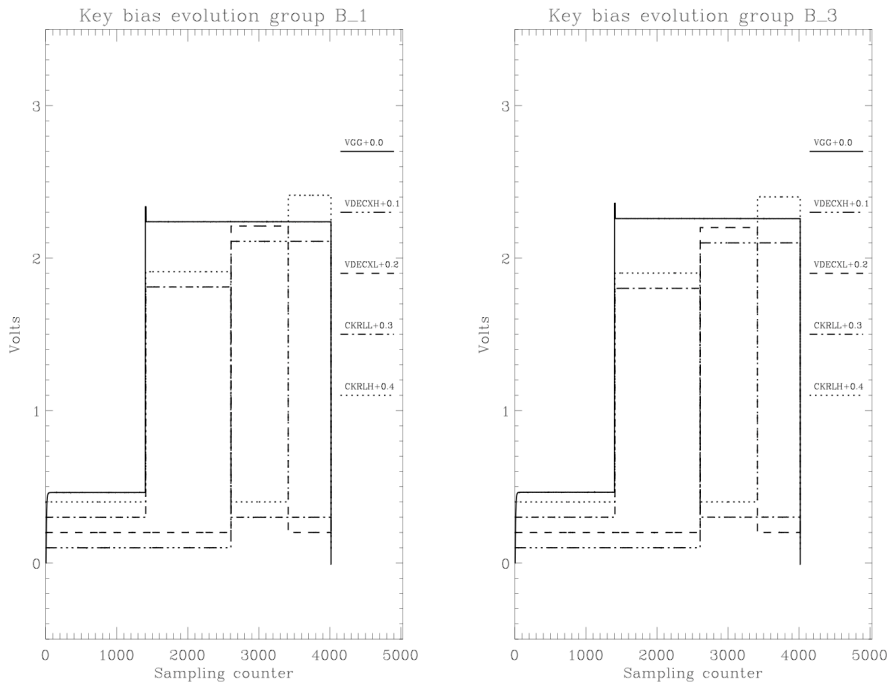


Table 9: Bias commanding checks for the last set for biases. A checkmark in the status column indicates that the command is correctly executed. For the BU biases, I indicate both the commanded value and that value corrected by GND-BU level in parenthesis. Units in the table are Volts. This table contains the values observed during test #1

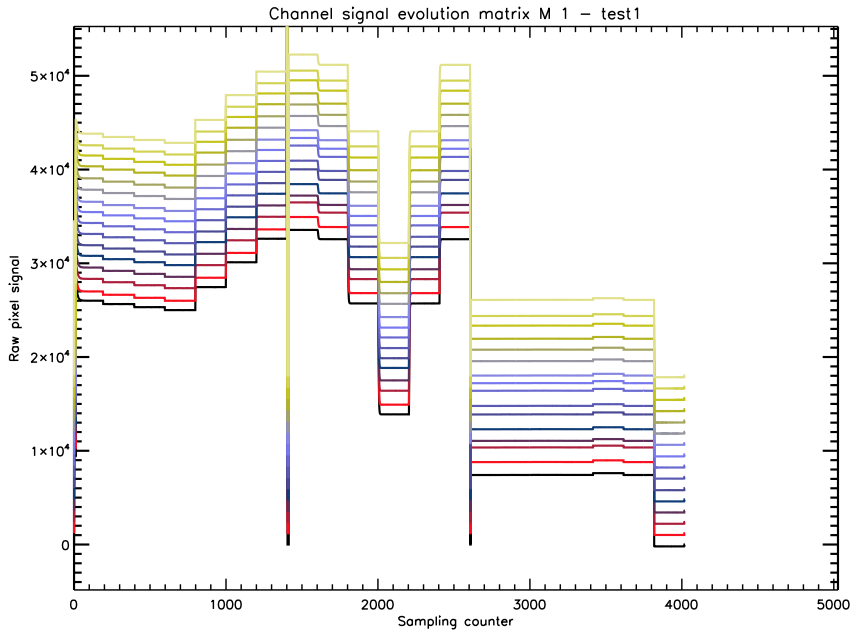
24/08/2006					
Bias name	Commanded values	Group 1		Group 3	
		Value	Status	Value	Status
VGL-BU	3.0 (3.46)	3.42	??	3.46	√
VDL-BU	4.2 (4.66)	4.60	??	4.65	√
VSS-BU	1.0 (1.46)	1.45	√	1.46	√
VGL	3.0	3.02	?	3.00	√
VDL	3.0	3.04	??	3.00	√
VSS	0.7	0.70	√	0.70	√
VSMS-L	3.0	3.01	√	3.00	√
VINJ	3.0	3.04	??	3.00	√

4.2.2 Signal analysis

We now turn to the data part of the telemetry. As explained above, because of the hardware configuration, one expects test #1 to have data at the location of M1 and M5, since we are looking at the red groups, and tests #2 and #3 to have data at the location of M1, M2, M5, M6. This is indeed the case, and so this is a relief[5].

The complete sequence: the signal analysis is rather straightforward. Since the signal is completely generated by the bias commands (i.e. none of it is due to the sensitive part of the bolometer), we only need to check one pixel per readout channel, i.e. 16 pixels per matrix. Because PIRE is a homemade IDL package, it is not completely straightforward to know which index of the arrays corresponds to the channel. To circumvent this, I have extracted the signal on pixels (i, i), with i from 0 to 15. I plot the timeline of each of these pixels and compare it to the reference one shown in RD1. All these timelines (160 in total) are shown in figure 8.

Figure 8: Signal timeline for the 16 channels of matrix M1 in test #1. This is one of the red matrix. Note that each timeline is artificially offset from the previous one for clarity. The first 4 downward steps correspond to the `VDD` sequence. The following 3 upward steps correspond to the `VH_BLIND` scale. They are followed by another upward step corresponding to the setting of `VH_BLIND` before the `VRL` scale. This `VRL` scale is the symetric 5-steps sequence. Then we have a long plateau that corresponds to the `VH-VL` sequence, invisible with this dynamical range (but see figure 9), followed by the sequence of readout modes **Sbolo_only**, **Sref_only** and **Sbolo−Sref**. For this last sequence we observe a clear difference with the reference sequence of RD1: the signal in the **Sbolo_only** is higher that in **Sref_only** here while the opposite is true in RD1. See the text for a discussion of this discrepancy.

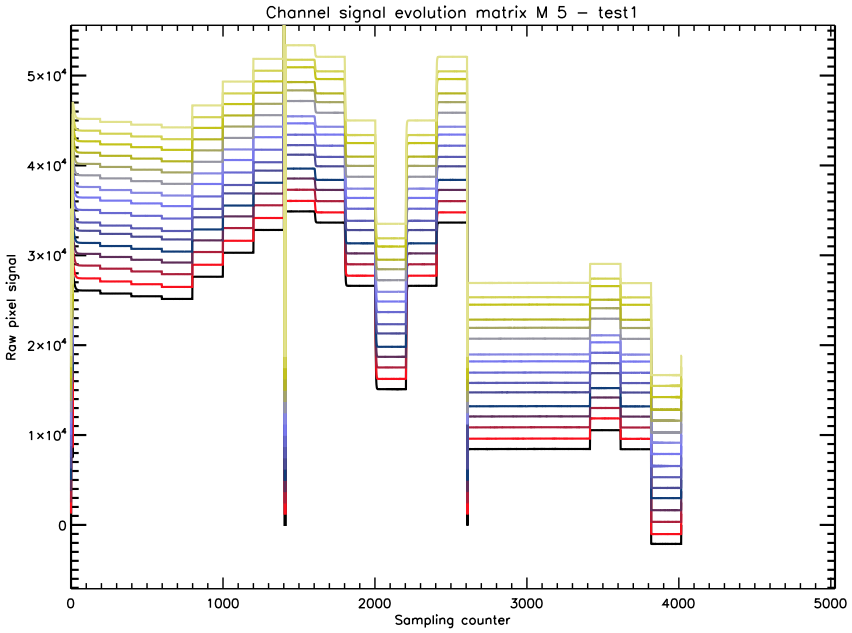


Each of the channels displayed on figure 8 except one[6] shows a similar pattern, which is a first good

[5] Remember also that PIRE is in IDL and thus the index of M1 is 0...

[6] This is the absent channel of matrix M8, so this is expected and part of the "success" criteria for the functional test.

Figure 8: Continued. Signal timeline for the 16 channels of matrix M5 in test #1. This is the other red matrix.



sign. This pattern is almost identical to that of RD1: the first 4 downward steps correspond to the `VDD` sequence. The following 3 upward steps correspond to the `VH_BLIND` scale. They are followed by another upward step corresponding to the setting of `VH_BLIND` before the `VRL` scale. This `VRL` scale is the symetric 5-steps sequence. Then we have a long plateau that corresponds to the `VH-VL` sequence, invisible with the full dynamical range (but see later), followed by the sequence of readout modes **Sbolo_only**, **Sref_only** and **Sbolo−Sref**. **It is for this last sequence that we observe a clear difference with the reference sequence of RD1**: the signal in the **Sbolo_only** is higher that in **Sref_only** here while the opposite is true in RD1.

The reason for this difference is not straightforward: it cannot be the different `VH_BLIND` levels used for this run, as the `VH_BLIND` differenciation is performed whatever the readout mode (see RD1). It should therefore not affect the relative positionning of the **Sbolo_only** and **Sref_only** signals. It is very unlikely that it is a result of the FM/QM1 commanding problem as this affects only group 1 biases yet both group 1 and group 3 signals show the same behavior.

Figure 8: Continued. Signal timeline for the 16 channels of matrices M1 and M2 in test #2. These are blue matrices.

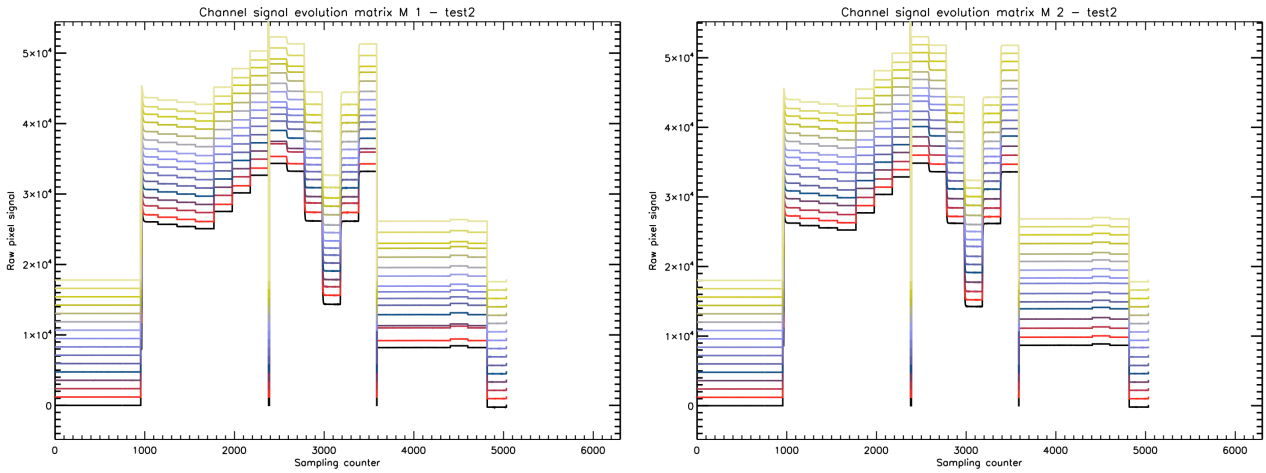


Figure 8: Continued. Signal timeline for the 16 channels of matrices M5 and M6 in test #2. These are blue matrices.

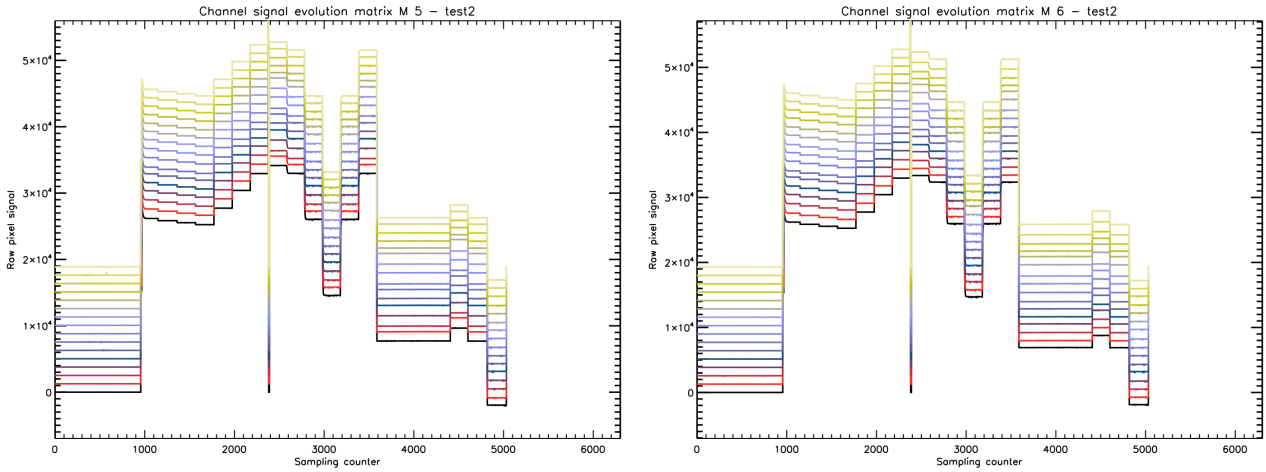


Figure 8: Continued. Signal timeline for the 16 channels of matrices M1 and M2 in test #3. These are blue matrices.

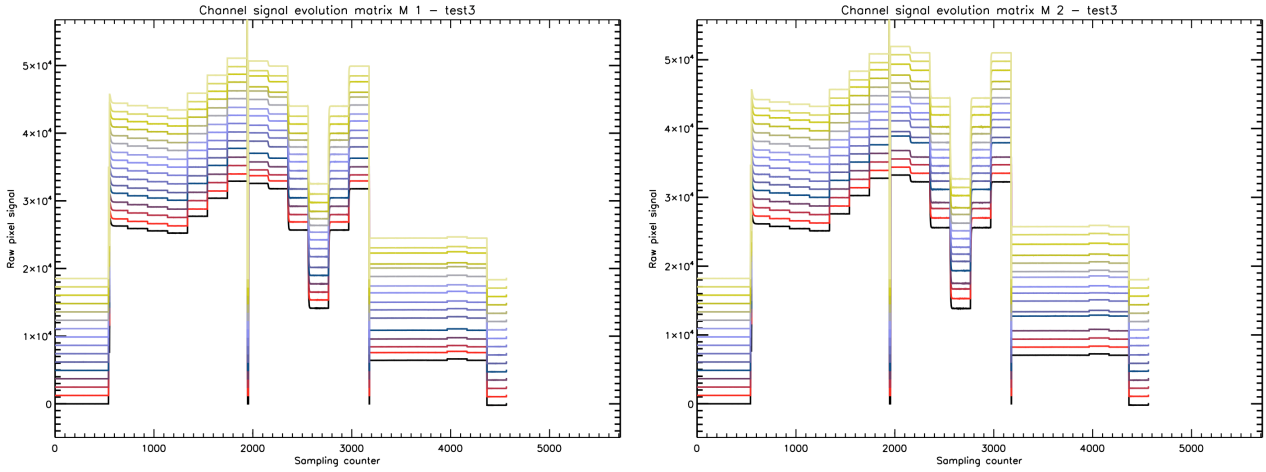
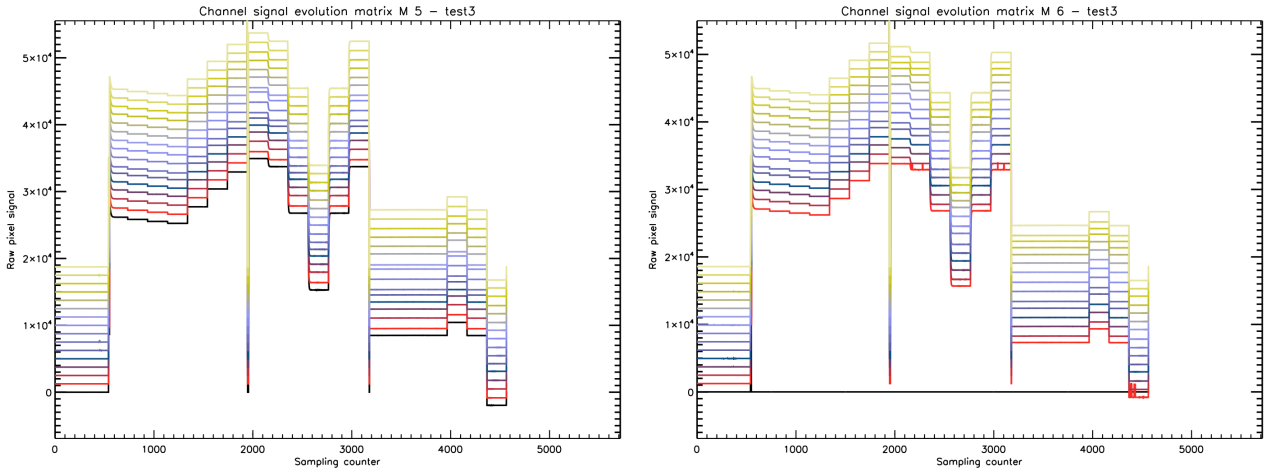


Figure 8: Continued. Signal timeline for the 16 channels of matrices M5 and M6 in test #3. These are blue matrices. The constant channel on the M6 panel allows the unambiguous identification of this matrix with matrix M8 of the PhFPU (see RD1).



The VH-VL sequence: When the instrument is warm, it is extremely hard to see the effect of the VH-VL sequence (see appendix A) when the full dynamical range is used. It is in fact also hard to clearly identify on a pixel level (VH and VL are used to adjust the value of the mid-point voltage, but when the system is warm this is very inefficient). Thus I have instead build the average signal per matrix and this is what is displayed on figure 9, with the value of VH and VL superimposed.

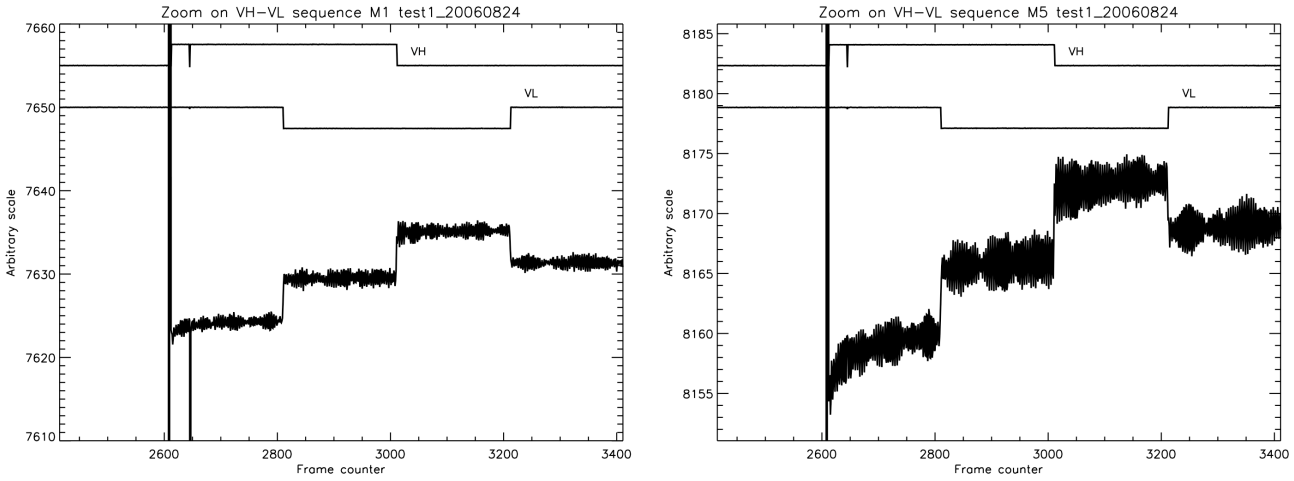


Figure 9: The VH-VL sequence as observed on the mean signal for matrices M1 and M5 during test #1. These are red matrices, and contrary to the following figures, they do not belong to the same BOLC group. The effect of changing the (VH, VL) biases is evident on the mean signal, while it is much more difficult to indentify at a pixel level. The transitory period that follows any bias change is most evident at the start of the sequence at this scale. Also evident is the presence of "non-white" noise on the data, expecially on M5, that is correlated between groups (this will become clearer on the next panels – see text for analysis).

As with the test of 17/07/2006, the first important point to stress is that the global behavior of the signal during the VH-VL sequence is as expected. Remember that VH and VL are used to adjust the level of the midpoint voltage, which is in fact the bolometer signal when the instrument is cold. As explained in RD1, in readout mode **Sref_only**, which is the mode where we read only the bolometer, the signal from the bolometer has a minus sign, therefore decreasing the midpoint level (either through a VH or a a VL decrease) will increase the signal level[7].

But again, as with the test performed on 17/07/2006, we see that we have an extra "non-white" noise component that is correlated between matrices of the same group and groups of the same test. I have again performed computations of the power spectra of these mean signals to characterize this noise source. Each sequence gives rise to 4 spectra as I have to compute one per value of the (VH, VL) pair. The exploration of the noise properties indicates again that we are picking up the general 50 Hz modulation from the lab's power supply, see figure 10. This is not very surprising as the hardware set-up is the same, i.e. we still suffer from the lack of complete shielding between BOLC QM1 and the PhFPU. There are two noticeable differences with the tests of 17/07/2006. First the noise level associated with the 10 Hz component is significantly higher here. I have compared the peak values observed for each sequence of each matrix during each test and found that **on 24/08/2006, they were 3 to 8 times larger than on 17/07/2006**. As the only identified difference lies in the test

[7]If you are lost now, it is either a sign that your training in the ways of Saclay's Fuzzy Logic^{TM}is not complete, or that you have not read RD1, each being terrible for your karma.

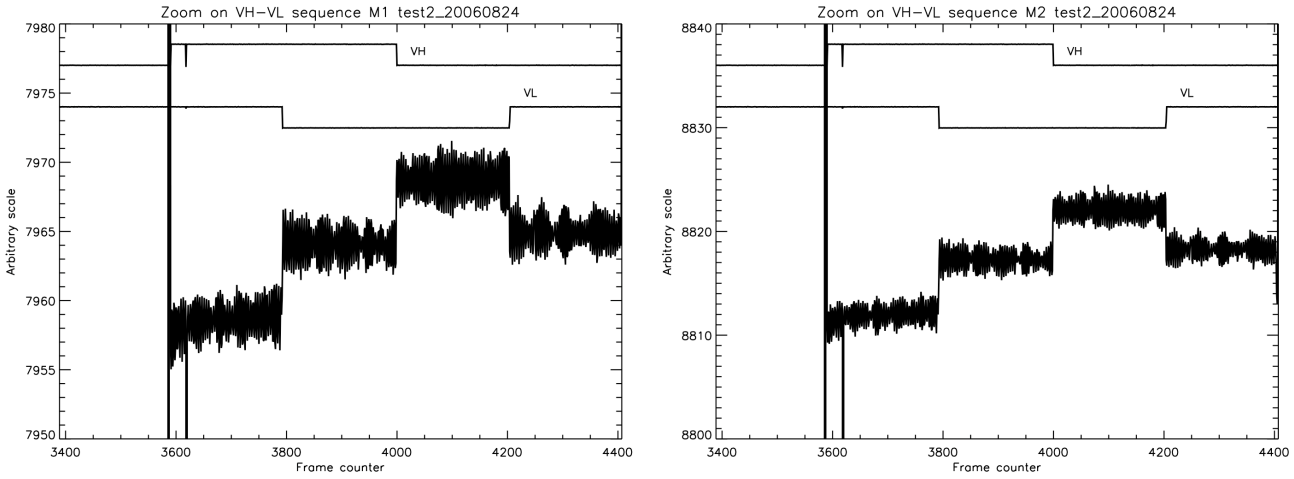


Figure 9: Continued. The VH-VL sequence as observed on the mean signal for matrices M1 and M2 during test #2. These are blue matrices, belonging to the same BOLC group. The presence of "non-white" noise on the data is clearer now, with a strong correlation between matrices of the same group.

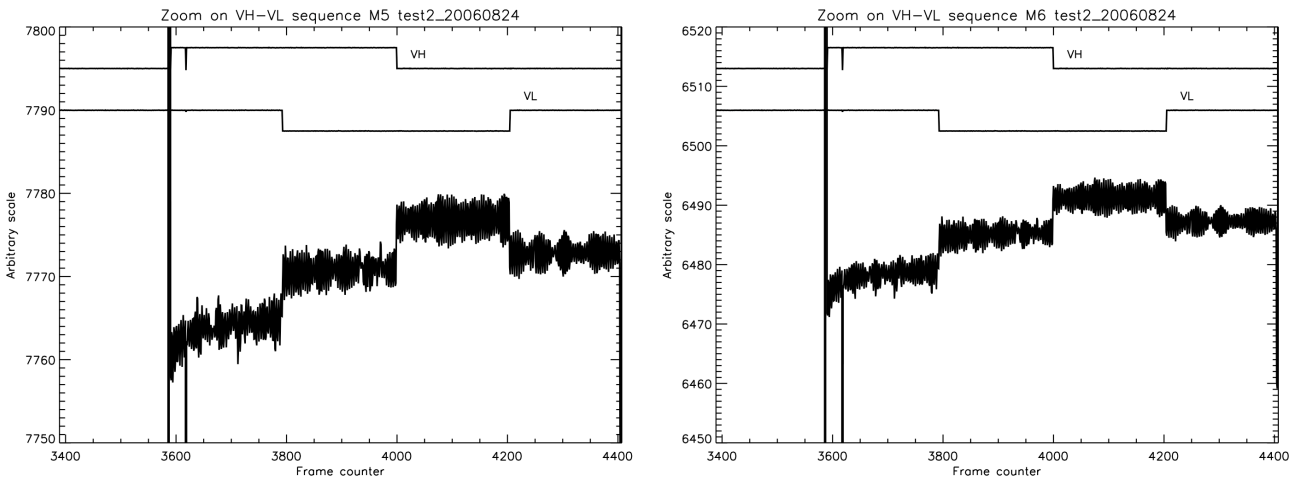


Figure 9: Continued. The VH-VL sequence as observed on the mean signal for matrices M5 and M6 during test #2. These are blue matrices, belonging to the same BOLC group. The "non-white" noise is indeed correlated between the two active groups of this test.

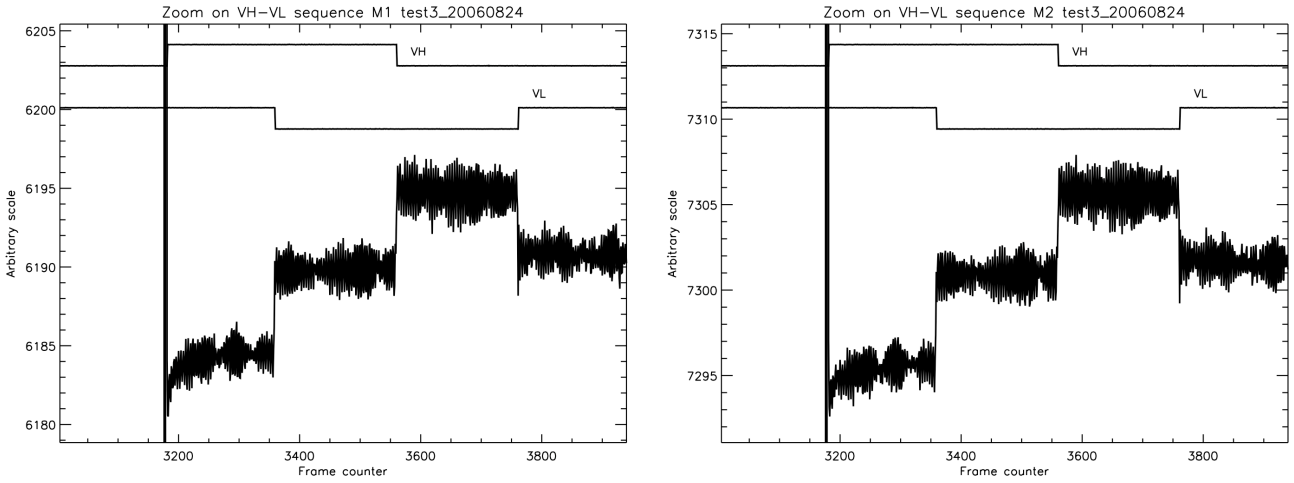


Figure 9: Continued. The `VH-VL` sequence as observed on the mean signal for matrices M1 and M2 during test #3. These are blue matrices, belonging to the same BOLC group.

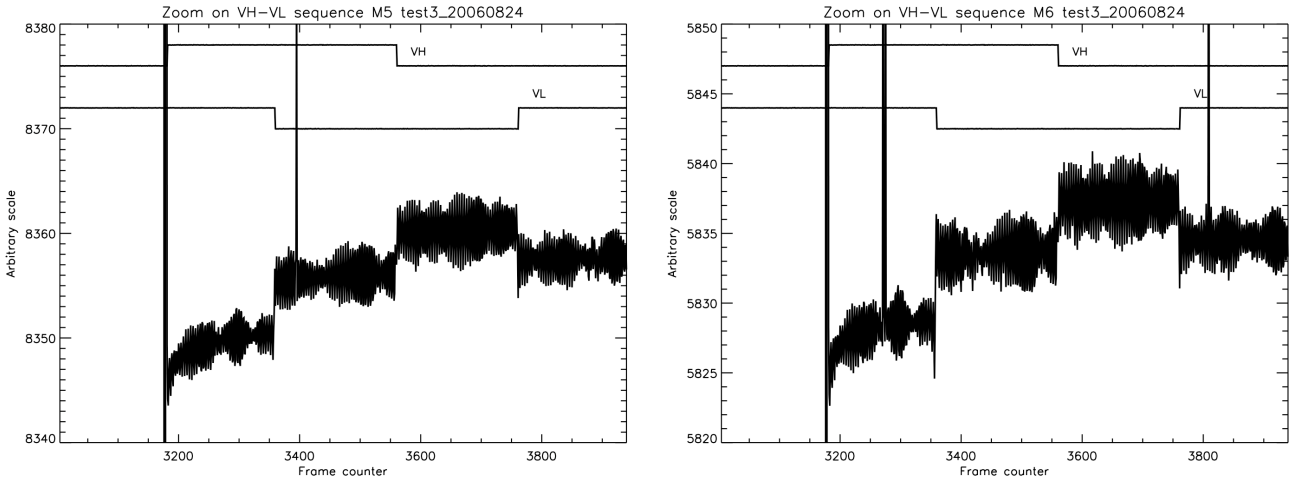


Figure 9: Continued. The `VH-VL` sequence as observed on the mean signal for matrices M5 and M6 during test #3. These are blue matrices, belonging to the same BOLC group.

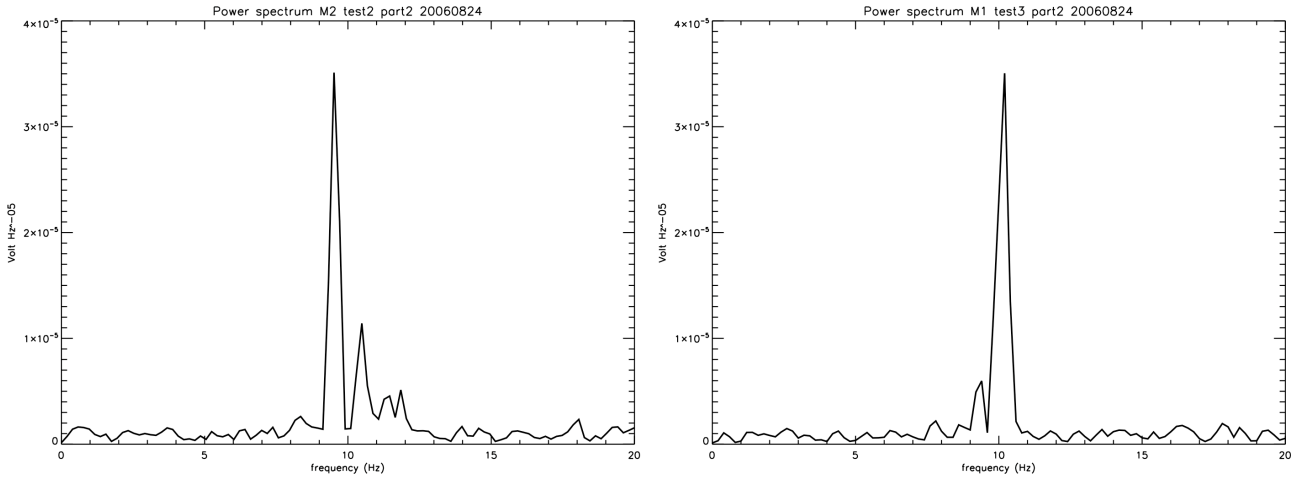


Figure 10: On the left panel, I show the power spectrum of the mean signal on matrix M2 observed during the second part of the VH-VL sequence (VH = 0.1, VL = −0.1) V of test #2. This panel is equivalent to figure 5 and immediately shows that the power in the 10 Hz component is much higher now (here the peak is 3.5 times higher). This also reveals a frequent situation where the peak has a lot of structure and its main component appears at a lower frequency. The origin of this effect is unknown but could be related to the small number of samples we have to compute the power spectra. On the right panel I show the power spectrum of the mean signal on matrix M1 during the same sequence, but this time from test #3. Here the peak is strong as well, and better centered at 10 Hz

location (MPE here, KT for the tests of 17/07/2006) we can only hope that the FM shielding will be efficient. Second we see sometimes the 10 Hz peak shifted to smaller frequencies (as on the left panel of figure 10) broadened to 2-3 Hz. It is impossible to tell whether this is an effect of the small number of samples (200) we have to compute the power spectrum. This leads me to recommend that we place, at the end of the VH-VL sequence, a longer wait time to accumulate frames that would be used to characterize and possibly identify any mysterious noise source that might affect the signal.

Finally, I have written earlier that the noise due to the 10 Hz component appears very correlated. This can be quantified. As an example I have used the second part of the VH-VL sequence. Working on the mean signal per matrix, I find that the correlation coefficient between M2 and M1 is 0.97, that between M6 and M5 is 0.99, and that between M6 and M1 is 0.96 . Given the hypothesized origin for the 10 Hz component, it is not surprising to find some correlation, especially on the mean signal per matrix. However these correlation levels indicate that most of the noise we observe is due to the 10 Hz component. I have made a small check on the pixel-level signal, using pixel [8,8] in the same sequence. The correlation coefficients, for the pixel signals, are 0.93 between M2 and M1, 0.98 between M6 and M5, and 0.97 between M6 and M1. Thus even on the pixel level, most of the noise is due to that 10 Hz component.

4.3 Conclusions

The objective of this test is to check that all electrical lines to the bolometers are functionning. This objective is fully reached here. However it is worth mentioning that:

- One has to check that the commanding conversion tables correspond to the version of the BOLC

hardware used.

- The relative level of the signal between the **Sref_only** and the **Sb_only** mode is different from that observed in SAp, and the origin of this is unknown. This relative position is the same as that observed in KT on 17/07/2006.
- We pick up an extra noise component with a characteristic frequency of 10 Hz, which is likely due to the general lab power supply 50 Hz frequency and the lack of complete shielding between BOLC QM1 and the FM PhFPU. This shielding will be complete when BOLC FM is used, nevertheless the levels observed at MPE for this component are much higher than those observed in KT.
- The current procedure is not adequate to quantify the noise on the signal (it was not meant to be). Since we do observe extra noise sources, it would be good to introduce a "waiting" plateau after the `VH-VL` sequence long enough to accumulate more than 200 samples on the signal.

5 The warm functional tests of 11/10/2006

5.1 Test Description

These tests were performed right at the start of the actual FM ILT. They used the FM version of BOLC and the SAp Local Test Unit. As such they form the reference against which the tests performed the following day with the PACS warm electronics and complete FM ILT setup can be compared. This time we can control the complete instrument (i.e. the 6 groups and the 10 matrices) at once. Since we have the FM hardware, we are almost back to using the test script described in RD1. Almost only as we found out that we need to add wait times after the commanding of the protection biases and `GND-BU`. This will in fact become the nominal bias setting procedure starting from Draft 7 of RD1.

The actual test execution is much simpler now, and here the complete test script was simply executed twice. Since the differences between the two run of the test are extremely small, I will not treat them separately.

5.2 Analysis

Similarly to the previous LTU-operated tests, these tests were analysed with PIRE, in a version that has been updated to handle correctly the different version of the commanding and HK conversion tables. We made sure to specify that FM Main versions had to be used here.

The next sections deal with the two steps of the analysis: the bias time sequence and the signal time signal. In this second section, we pay special attention to the noise characteristics.

5.2.1 Bias commands execution

As usual here we first need to record the values of `GNB-BU` as this voltage will be added to all the BU bias values. These values are listed in table 10. They have changed slightly since the previous test but this can be attributed to the major change that constitutes the replacement of BOLC-QM1 by BOLC-FM.

Table 10: The median value of `GND-BU` measured during the LTU tests. The units are Volts. The values are exactly the same between the two tests, therefore only the values measured during test #1 are shown.

11/10/2006					
Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
0.457	0.458	0.455	0.457	0.459	0.459

As usual, to simplify the inspection of the commanding, I group the HK into three sets: those that are used to modulate the signal during the test, those that are modified so that the signal can be observed, and those that are set only once.

The comparison between the commanding and the HK for the first set of bias is displayed in table 11 in the time order in which the commanding is made and graphically on the left panel of figure 11. I only show the values observed on group 1 as all the other groups show identical sequences, once the marginal difference due to the "all-group" commanding method are taken into account.

Table 11 shows that contrary to what we have observed so far, all biases reach their commanded value

Table 11: Bias commanding checks for the 5 most important biases of the test. This is a time-ordered table though the timing of the commands is not indicated. A checkmark in the status column indicates that the command is correctly executed. Units in the table are Volts. For the BU biases, I indicate both the commanded value and that value corrected by GND-BU level in parenthesis. This table contains the time sequence for group 1. Identical sequences are observed for the other groups, with marginal differences due to the "all-group" commanding method.

11/10/2006						
Bias setting values					Group 1	
VH_BLIND	VDD	VRL	VH	VL	Value	Status
1.20					1.20	√
	1.20 (1.66)				1.66	√
	1.22 (1.68)				1.68	√
	1.24 (1.70)				1.70	√
	1.26 (1.72)				1.72	√
1.22					1.22	√
1.24					1.24	√
1.26					1.26	√
	2.60 (3.06)				3.06	√
1.80					1.80	√
		0.30			0.30	√
		0.40			0.40	√
		0.50			0.50	√
		0.40			0.40	√
		0.30			0.30	√
1.15					1.15	√
			0.10		0.10	√
				−0.1	−0.10	√
			0.00		0.00	√
				0.00	0.00	√

on all groups. In other terms the commanding system appears to work as long as the right conversion tables are used.

This impression is confirmed when we turn to the second set of bias, which is again shown as a time ordered sequence on table 12 and graphically on the right panel of figure 11. As can be seen from the table, the commands are all perfectly executed.

Finally we examine the last set of bias. Since those are commanded only once, there is no need to build a timeline and table 13 simply shows the commanded and observed values. This table contains one question mark, which could ruin the impression given by the previous tables. However inspecting the biases on the other groups shows that this is an exception. Therefore the conclusion of this examination of the commanding is that **on 11/10/2006, commanding was perfectly executed**.

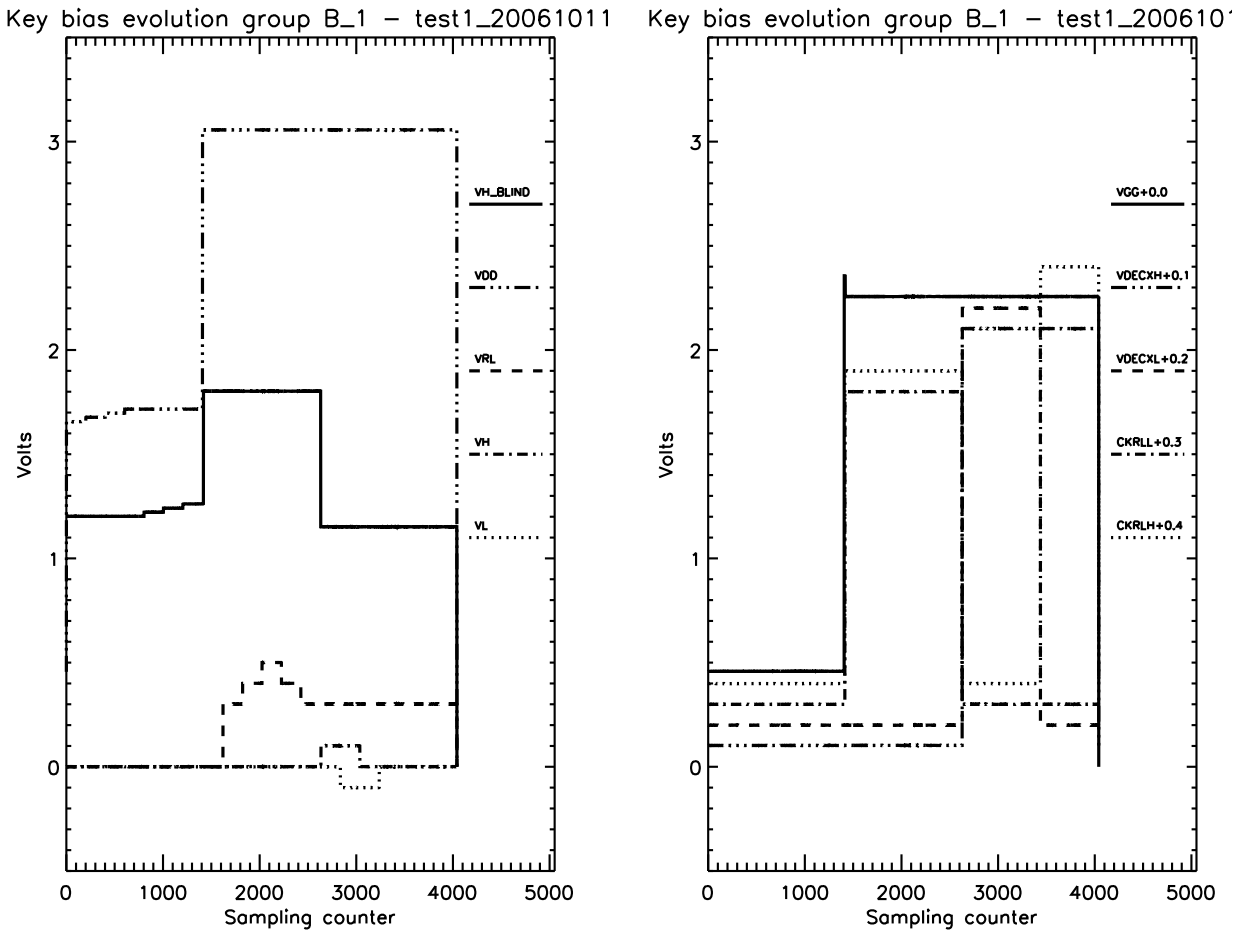


Figure 11: Left panel: time evolution for the 5 most important biases generating the test signal. Right panel: time evolution for the second set of biases. Units on this figure are Volts. Note that to produce a clean figure, I have median-filtered the HK values. On the figure, I give the actual HK values, uncorrected for the GND-BU level. This figure shows only group 1 data as all the other figures are identical.

Table 12: Bias commanding checks for the second bias set of the test. This is a time-ordered table though the timing of the commands is not indicated. A checkmark in the status column indicates that the command is correctly executed. For the BU biases, I indicate both the commanded value and that value corrected by GND-BU level in parenthesis. Units in the table are Volts. Only group 1 is show, but all the other groups show the same behavior.

11/10/2006						
Bias setting values					Group 1	
VGG	VDECX-H	VDECX-L	CKRLL	CKRLH	Value	Status
0.0 (0.46)					0.46	√
1.9 (2.36)					2.36	√
	0.0				0.00	√
		0.0			0.00	√
				1.5	1.50	√
			1.5		1.50	√
1.8 (2.26)					2.26	√
				0.0	0.00	√
			0.0		0.00	√
	2.0				2.00	√
		2.0			2.00	√
		0.0			0.00	√
				2.0	2.00	√

Table 13: Bias commanding checks for the last set for biases. A checkmark in the status column indicates that the command is correctly executed. For the BU biases, I indicate both the commanded value and that value corrected by GND-BU level in parenthesis. Units in the table are Volts. This table contains the values observed on group 1.

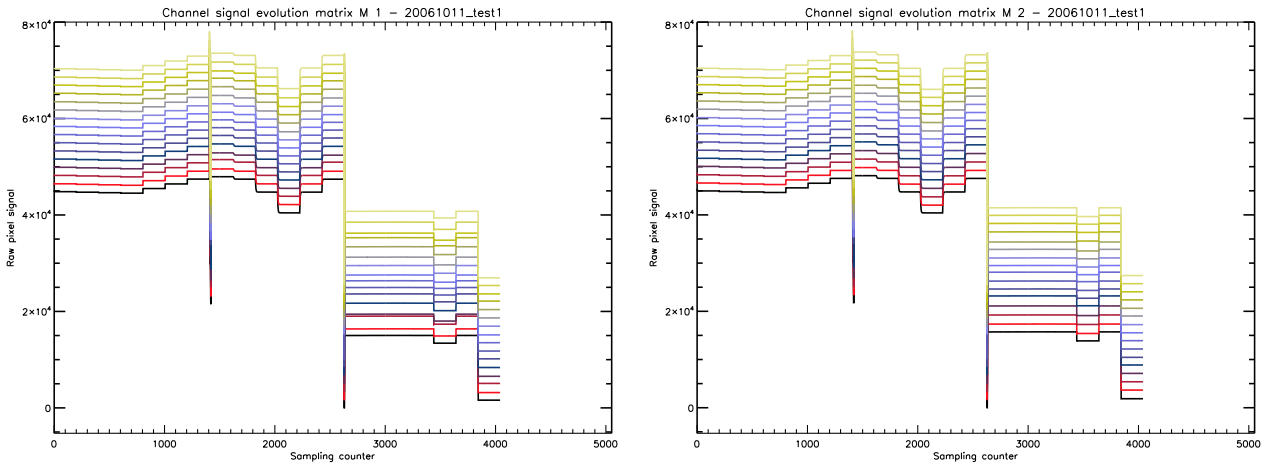
11/10/2006			
Bias name	Commanded values	Group 1	
		Value	Status
VGL-BU	3.0 (3.46)	3.47	√
VDL-BU	4.2 (4.66)	4.68	?
VSS-BU	1.0 (1.46)	1.46	√
VGL	3.0	3.00	√
VDL	3.0	3.00	√
VSS	0.7	0.70	√
VSMS-L	3.0	3.00	√
VINJ	3.0	3.00	√

5.2.2 Signal analysis

Compared to previous test occurences, it will now be much simpler to identify the signals since now we have everything in its right place (i.e. M1 is at the location of M1, M2 of M2, and so on up to M10). Therefore I no longer need to specify that they are blue or red.

The complete sequence: Since the signal is completely generated by the bias commands, I only check pixels (i, i) on each matrix. Thus for each matrix I have 16 timelines that I plot on figure 12, each displaced by a small amount from the previous one for clarity's sake. The data are displayed as raw values as converting them to volts make little sense at this stage.

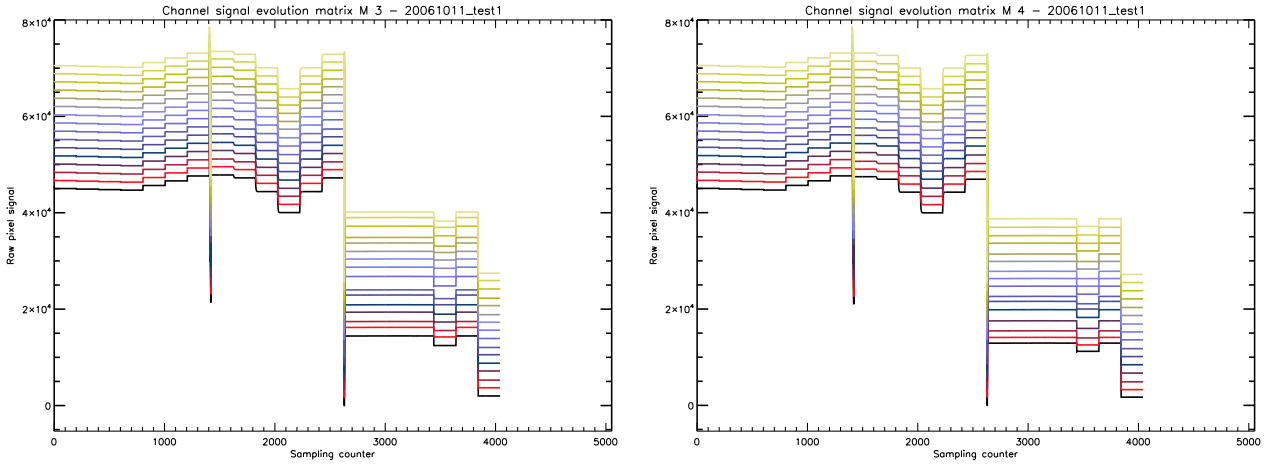
Figure 12: Signal timeline for the 16 channels of matrices M1 and M2. Note that each timeline is artificially offset from the previous one for clarity. The first 4 downward steps correspond to the `VDD` sequence. The following 3 upward steps correspond to the `VH_BLIND` scale. They are followed by another upward step corresponding to the setting of `VH_BLIND` before the `VRL` scale. This `VRL` scale is the symetric 5-steps sequence. Then we have a long plateau that corresponds to the `VH-VL` sequence, invisible with this dynamical range (but see figure 13), followed by the sequence of readout modes **Sbolo_only**, **Sref_only** and **Sbolo−Sref**. For this last sequence we observe now a behavior similar to the reference sequence of RD1: the signal in **Sbolo_only** is lower that in **Sref_only**. See the text for a discussion of this return to the normal situation. The data plotted here come from the first run of the test.



Each of the channels displayed on figure 12 except one[8] shows a similar pattern, which is a first good sign. This pattern is this time identical to that of RD1: the first 4 downward steps correspond to the `VDD` sequence. The following 3 upward steps correspond to the `VH_BLIND` scale. They are followed by another upward step corresponding to the setting of `VH_BLIND` before the `VRL` scale. This `VRL` scale is the symetric 5-steps sequence. Then we have a long plateau that corresponds to the `VH-VL` sequence, invisible with the full dynamical range (but see later), followed by the sequence of readout modes **Sbolo_only**, **Sref_only** and **Sbolo−Sref**. **We now observe the same behaviour as in**

[8]This is the absent channel of matrix M8, which is observed for the first time at the correct telemetry location since we can now operate the complete PhFPU with BOLC. Therefore this is really part of the "success" criteria for the functional test.

Figure 12: Continued. Signal timeline for the 16 channels of matrices M3 and M4.



the reference sequence of RD1: the signal in the **Sbolo_only** is lower that in **Sref_only** (you will *need* to read the PhFPU user's manual, RD1, to understand why this is compatible with the fact the the signal in **Sbolo−Sref** mode is still positive). This is welcome. However we can only conclude that the relative position of these two modes in terms of signal level is driven by the warm electronics, and for this we have no good explanation.

Figure 12: Continued. Signal timeline for the 16 channels of matrices M5 and M6.

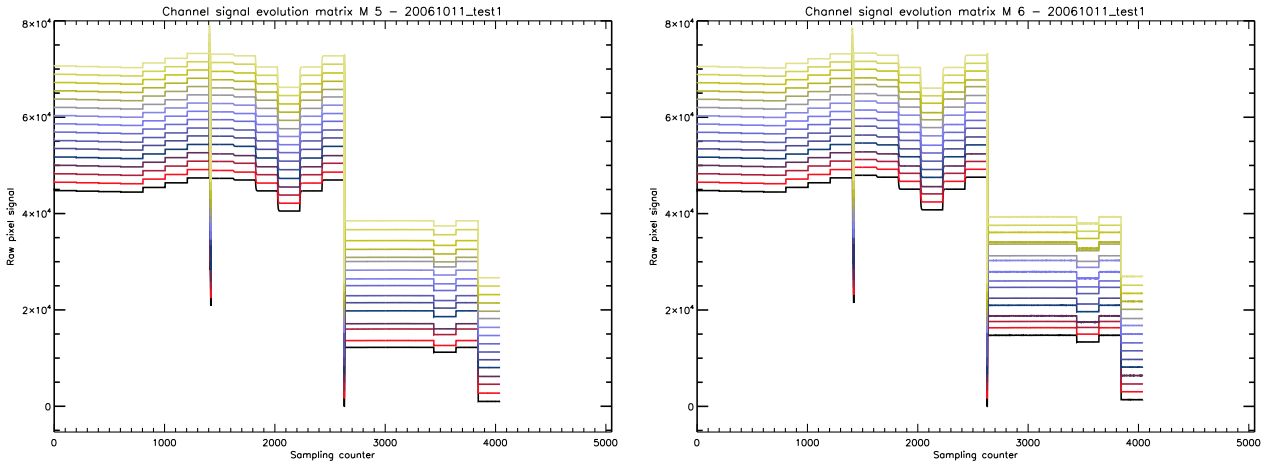

Channel signal evolution matrix M 5 – 20061011_test1
Channel signal evolution matrix M 6 – 20061011_test1
Raw pixel signal
Sampling counter

Figure 12: Continued. Signal timeline for the 16 channels of matrices M7 and M8.

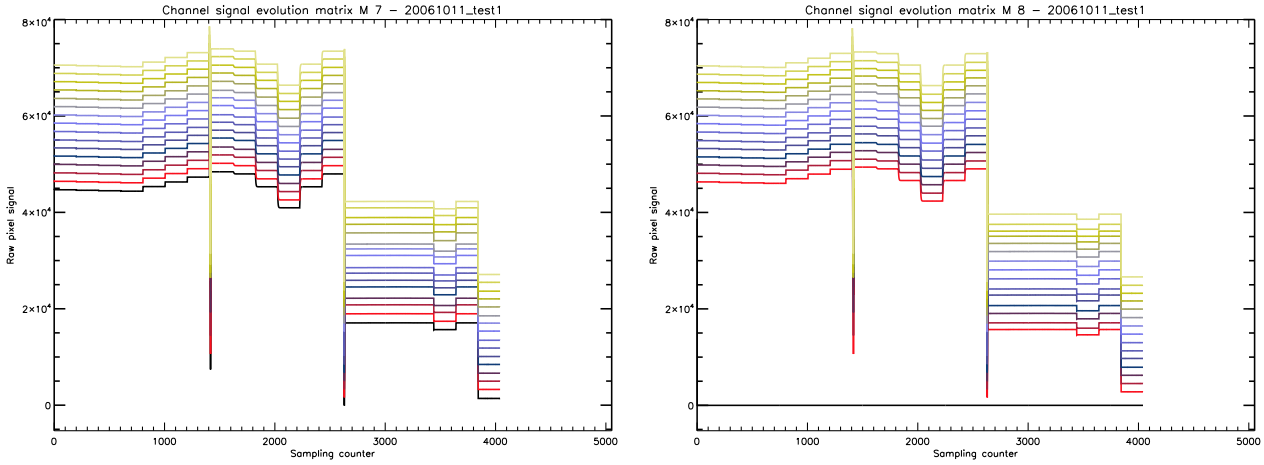
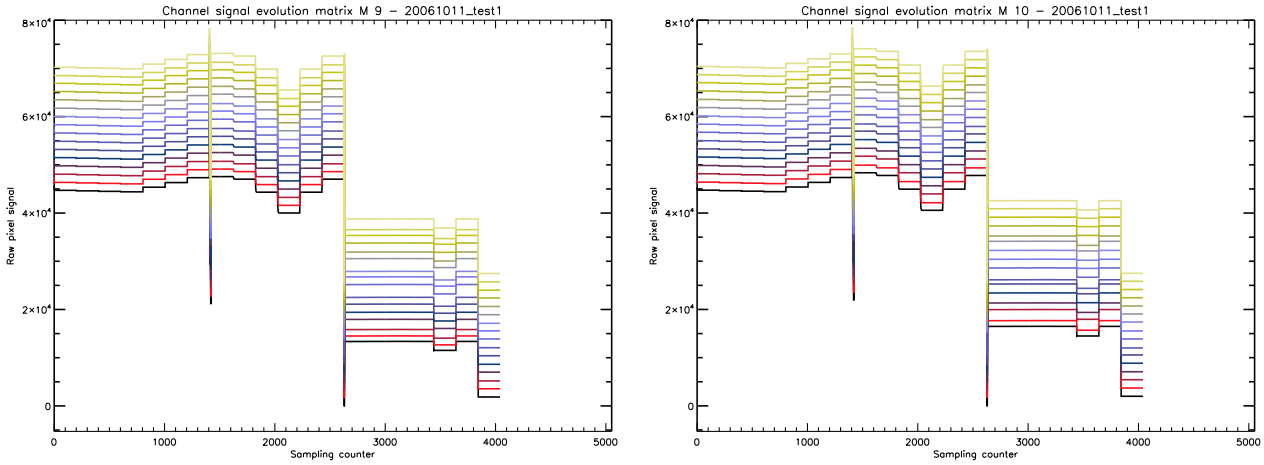

Channel signal evolution matrix M 7 – 20061011_test1
Channel signal evolution matrix M 8 – 20061011_test1
Raw pixel signal
Sampling counter

Figure 12: Continued. Signal timeline for the 16 channels of matrices M9 and M10.



The VH-VL sequence Since the instrument is still warm I again examine here the behavior of the mean signal per matrix during the VH-VL sequence. Figure 13 shows this sequence for each matrix with the VH and VL sequences superimposed for clarity.

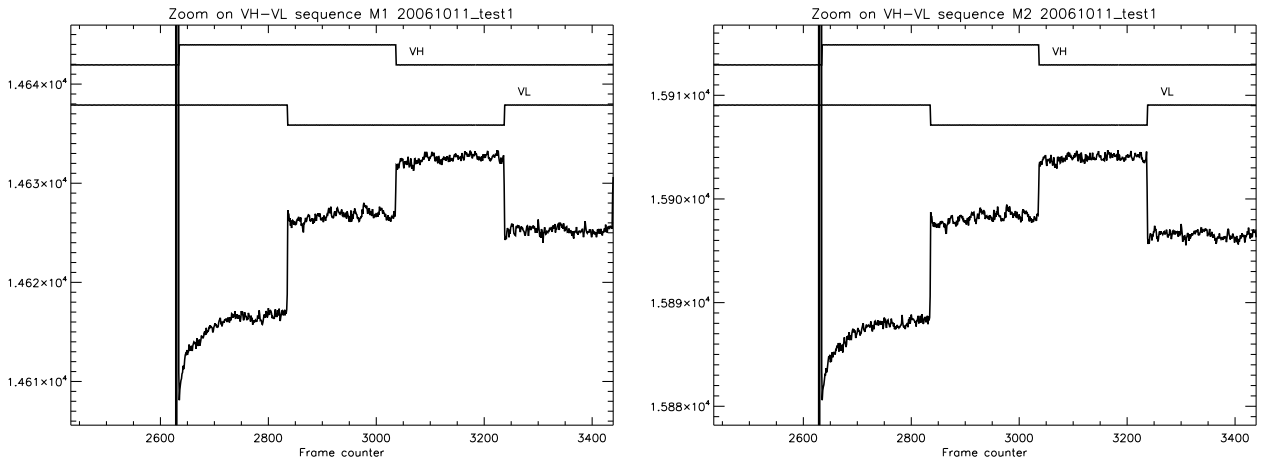


Figure 13: The VH-VL sequence as observed on the mean signal for matrices M1 and M2. The effect of changing the (VH, VL) biases is evident on the mean signal, while it is much more difficult to indentify at a pixel level. The transitory period that follows any bias change is most evident at the start of the sequence at this scale. The "non-white" noise that was apparent in previous test is gone, but the strong correlations between matrices of a given group is still clear.

This series of figure reveals that the 10 Hz component observed in previous tests is gone. This was expected since the shielding is much better when the complete FM setup is used, but it is nevertheless a relief. The power spectrum plots for the VH-VL sequence do not reveal any interesting feature so I have not displayed them. Similarly to what I had done previously, I have looked at the correlation coefficients between the mean signals. I again find that there is a very high level of correlation (> 0.9) between the mean signals of two matrices belonging to the same group (which is not very surprising given that the signal is completely command-driven), except for group 3, which is principally due to the high noise level of matrix 6. Now that the 10 Hz component has disappeared, the correlation coefficient between signals of matrices belonging to different group is compatible with the absence of correlation. Therefore at this stage we can probably say that in a sequence where the signal is purely generated by the electronics, there is a strong correlation between signal observed on circuits that have a large number of components in common (such as within a group), but this correlation disappears when one compares signals generated through different circuits.

5.3 Conclusions

For this test, all the red lights recorded previously have now turned to green, though we can provide little explanations for some of these favorable changes:

- Now that the conversion tables are compatible with the test equipment, we find that the agreement between the commanding and the HK values is nominal.
- The relative level of the signal between the **Sref_only** and the **Sb_only** modes is back to what

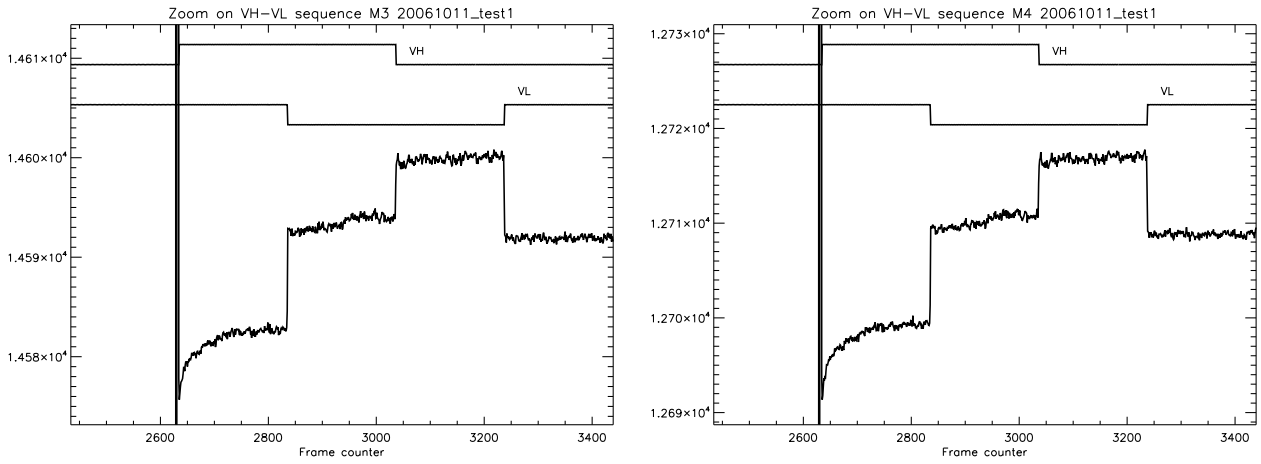


Figure 13: Continued. The `VH-VL` sequence as observed on the mean signal for matrices M3 and M4.

we observed in SAp. This can only mean that this relative positioning is driven by the BOLC model though we have no explanation for this.

- The extra noise component is gone. This was expected since the shielding of the complete FM configuration is much better that the shielding for the QM1-FM configuration used previously. As a result, the correlation, or absence thereof, between different signals is much easier to understand.

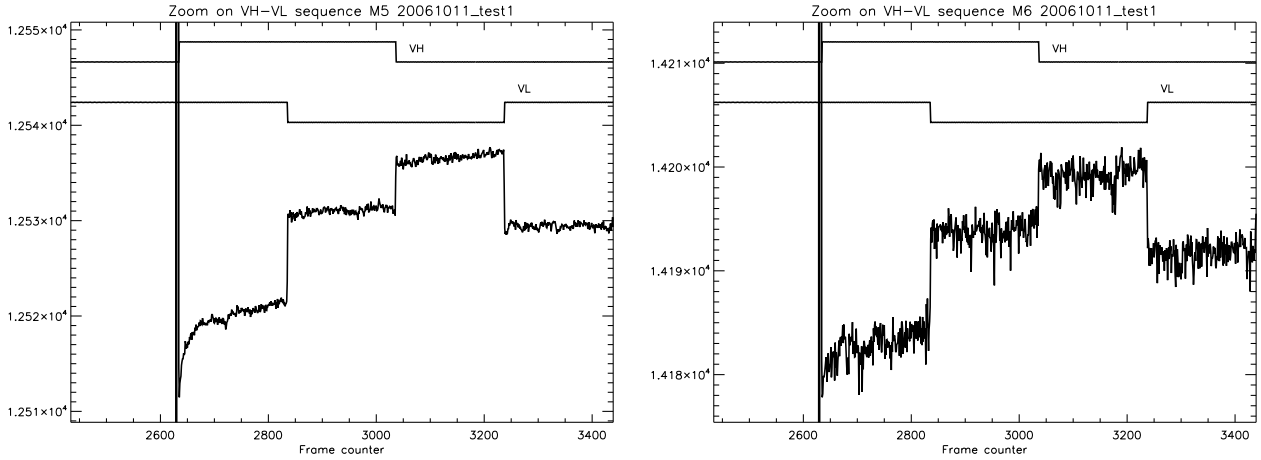


Figure 13: Continued. The `VH-VL` sequence as observed on the mean signal for matrices M5 and M6. In both tests performed that day, the noise level on matrix 6 was significantly higher than that observed on the other matrices.

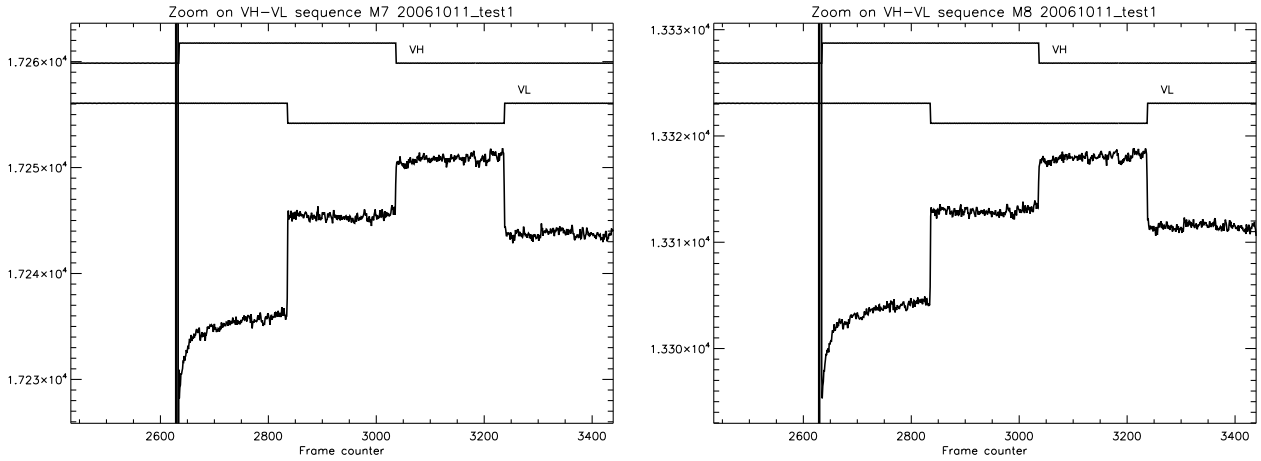


Figure 13: Continued. The `VH-VL` sequence as observed on the mean signal for matrices M7 and M8.

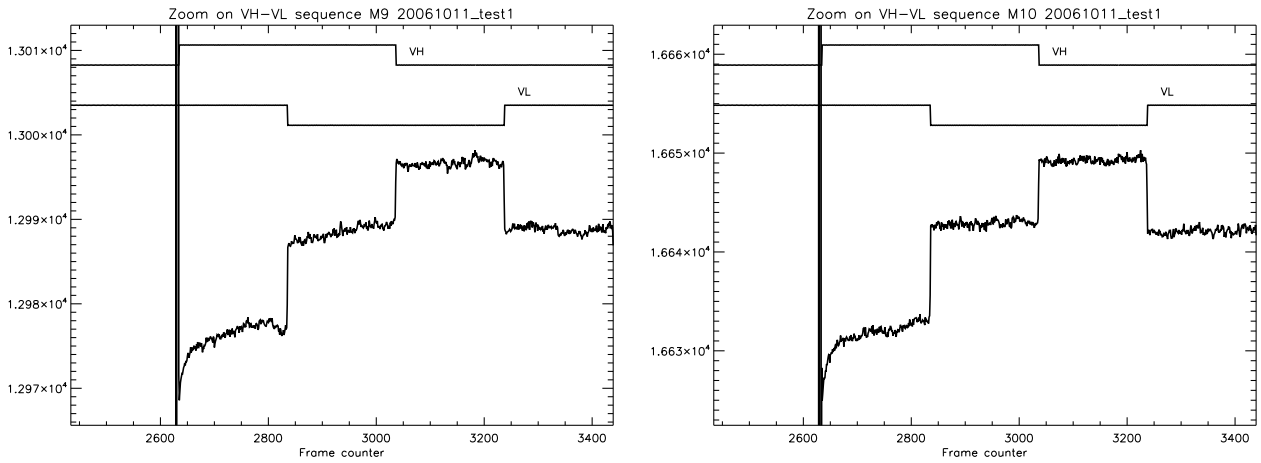


Figure 13: Continued. The `VH-VL` sequence as observed on the mean signal for matrices M9 and M10.

6 The LTU-driven 4 K functional tests of 31/10/2006

In principle, these tests were not supposed to happen. The LTU's last use should have occured on October 11, at which point control, and cable connection, was to be surrendered to PACS. However the repetition of the warm functional test using the PACS FM set-up on October 12 and later on October 17 revealed mysterious problems (group 6 was on at the start of the October 12 test and matrix 10, which is on group 6, showed dramatic signal drifts during both tests) that led us to re-open the LTU box and perform another series of LTU driven tests.

6.1 Test Description

The aim with this series of test was to perform an LTU test that would be as close as possible to the CUS-driven test, in order to eliminate all possible sources of difference, in case the results observed with these two set-ups would not be the same. To that effect we introduced artificial delays in the LTU-driven test. Eventhough we performed more than one test (with or without the delays), I am only going to present here the results from the last LTU run where the delays are as close as possible to those introduced by the CUS (if need be, I will refer to this test as the "CUS-like" test). No execution or signal difference was observed between the different runs. On October 31, this was the 4 fourth test executed. The actual script can be found in Appendix A.

6.2 Analysis

This analysis is done with PIRE, with the same version as that used to analyse the tests of October 11 (PIRE does not evolve much).

6.2.1 Bias commands execution

The first step is to check the values of `GND-BU` as it is added to all the BU HKs and needs to be taken into account when checking the correct execution of bias commands. The measured values are given in table 14. Note that these values are exactly the same as those observed on 11/10/06. This is supposed to be the case but it nevertheless reassuring.

Table 14: The median value of `GND-BU` measured during the LTU test. The units are Volts. Only those values observed during the CUS-like test are shown.

31/10/2006					
Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
0.457	0.458	0.455	0.457	0.459	0.459

Let us now turn to the three sets of housekeepings (these three sets are defined as 1: the set of biases that are used to generate the signal, 2: the set of biases that need to be commanded so that we see the signal and that are commmanded more than once, and 3: the set of biases that are only commanded once).

The comparison between the commanded values and the HK for the first set is shown as a time-ordered sequence in table 15. Note that since this is a 4 K level test, some of the commanded biases are different from what we have seen before. Also worth mentionning are the extra `VRL` steps. These

come from the fact that we repeat a part of the VRL scale on a group per group basis (rather than on the usual "all-groups" basis). The bias sequence of this first set is also shown graphically on figure 14. Here again I will only show in detail what is observed on group 1. No major difference is observed between groups apart from that due to the "all-groups" commanding scheme.

Table 15: Bias commanding checks for the 5 most important biases of the test. This is a time-ordered table though the timing of the commands is not indicated. A checkmark in the status column indicates that the command is correctly executed. Units in the table are Volts. For the BU biases, I indicate both the commanded value and that value corrected by GND-BU level in parenthesis. This table contains the time sequence for group 1. Identical sequences are observed for the other groups, with marginal differences due to the "all-groups" commanding method. Note that since this is a 4 K-level test the commanded biases are different from those used at 300 K.

31/10/2006						
Bias setting values					Group 1	
VH_BLIND	VDD	VRL	VH	VL	Value	Status
1.50					1.50	√
	1.40 (1.86)				1.86	√
	1.42 (1.88)				1.88	√
	1.44 (1.90)				1.80	√
	1.46 (1.92)				1.82	√
1.52					1.52	√
1.54					1.54	√
1.56					1.56	√
	2.60 (3.06)				3.06	√
1.75					1.75	√
		0.20			0.20	√
		0.30			0.30	√
		0.40			0.40	√
		0.50			0.30	√
		0.20			0.20	√
		0.40			0.40	√
		0.20			0.20	√
1.70					1.70	√
			0.50		0.50	√
				−0.15	−0.15	√
			0.00		0.00	√
				0.00	0.00	√

Inspection of table 15 reveals that all commands are nominally executed. This is true for all 6 groups of BOLC. Figure 14 is familiar but nevertheless shows new features that are worth commenting as this test is in fact the reference LTU-operated 4 K level test.

First, contrary to the test of October 11, we see the setting of almost all biases. This is quite noticeable on the BU biases that now start with a 0 V value (see for instance VDD). This is due to three reasons: (1) the command to start downlinking telemetry has been moved to the start of the script (see Appendix A), (2) because of this shift, we can see the effect of the delays introduced at the setting of the protection biases and of GND-BU (and that now form the standard procedure to bias the detectors), and (3) artificial delays are introduced after each command to simulate the fact that with the flight commanding equipment we cannot send more than two commands per second. Continuing on the VDD example, after the telemetry is requested, it takes 4 s to switch on GND-BU and another

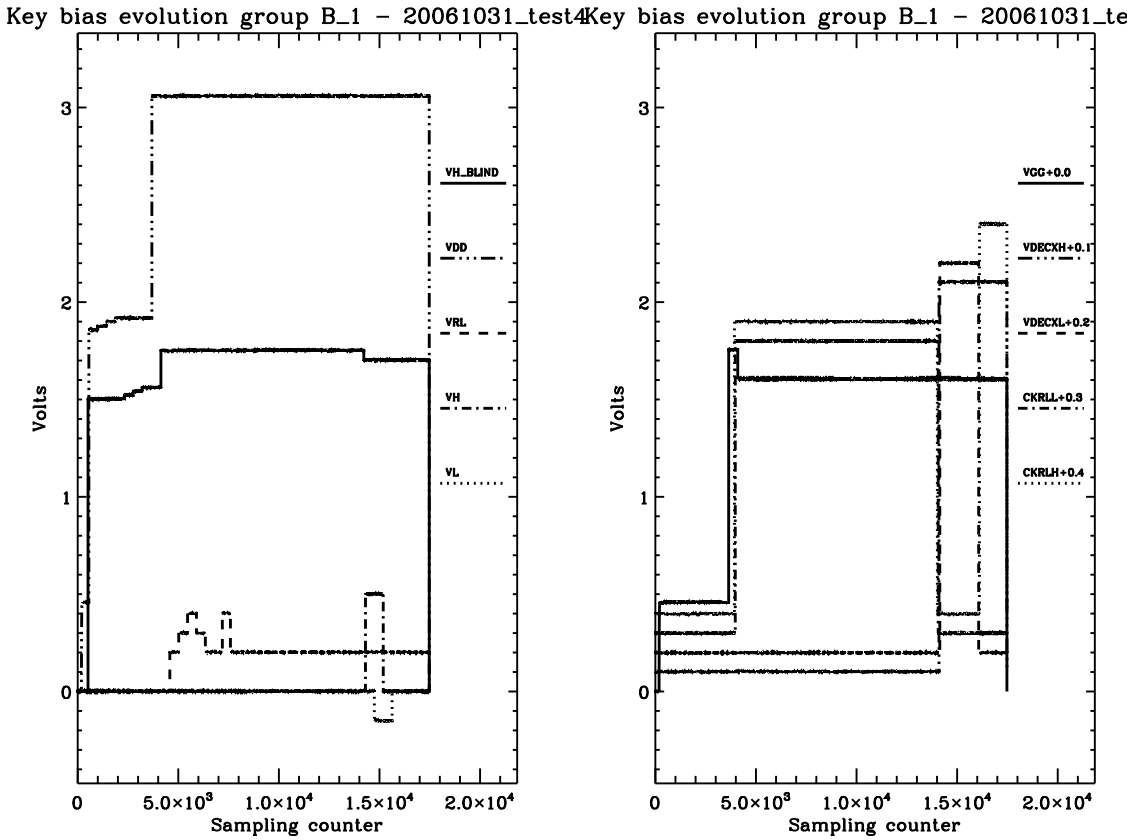


Figure 14: Left panel: time evolution for the 5 most important biases generating the test signal. Right panel: time evolution for the second set of biases. Units on this figure are Volts. On the figure, I give the actual HK values, uncorrected for the GND-BU level. This, and the fact that we have now introduced delays between each commands, explains why, for instance, VDD shows an intermediate level around 0.46 V, which does not appear in table 15. This only signals the switching on of GND-BU that occurs some time before the commanding of VDD. This figure shows only group 1 data as all the other figures are identical.

9 s to set VDD to its first commanded value. Previously, all the action before the setting of GNB-BU was happening before the downlinking of the telemetry, and all commands from the GND-BU setting to the biasing of VDD proceeded almost instantaneously. Note that the artificial delays could also be seen with keen eyes and thinner lines as now *all of the bias settings occur at different times.*

Second, we see a new step on VRL. This corresponds to a repetition of a part of the VRL scale on a group per group basis. This is why so much time elapses between that repetition on group 1 and the VH-VL sequence: we need time to repeat the VRL scale on each of the remaining 5 groups successively.

Finally, the values used for the VH-VL sequence are different here.

The second set of bias is explored now. In table 16 we give the time line of bias commands, while this timeline is also shown graphically on the right panel of figure 14.

Inspection of the housekeepings for the second set of biases (table 16) reveals again that the commanding is nominal. The right panel of figure 14 is also familiar and as the left panel shows the effect of the artificial commanding delays (see for instance the evolution of VGG: what used to be a very

Table 16: Bias commanding checks for the second bias set of the test. This is a time-ordered table though the timing of the commands is not indicated. A checkmark in the status column indicates that the command is correctly executed. For the BU biases, I indicate both the commanded value and that value corrected by the GND-BU level in parenthesis. Units in the table are Volts. Only group 1 is show, but all the other groups show the same behavior. Note again some subtle differences in the commanded bias levels with respect to the 300 K level tests.

31/10/2006						
Bias setting values					Group 1	
VGG	VDECX-H	VDECX-L	CKRLL	CKRLH	Value	Status
0.00 (0.46)					0.46	√
1.30 (1.76)					1.76	√
	0.0				0.00	√
		0.0			0.00	√
				1.5	1.50	√
			1.5		1.50	√
1.15 (1.61)					1.61	√
				0.0	0.00	√
			0.0		0.00	√
	2.0				2.00	√
		2.0			2.00	√
		0.0			0.00	√
				2.0	2.00	√

short spike on the way to its high level is now a minor plateau. Again the purpose of these artificial delays is to make the LTU-driven test as similar as possible to the CUS-driven test. This way visual checking of the functional test success is easier and we rule out commanding as a potential source of problems in the test execution or behavior.

Finally in table 17 we show the measured values of the last set of biases. We find here exactly the same results as on October 1: all biases are nominally commanded except VDL-BU which is sligthly discrepant on group 1. This is due to the "all-groups" commanding scheme.

Therefore we conclude that as far as the commanding is concerned, **the LTU-operated 4 K level test of 31/10/2006 was perfectly executed**. Let us now turn to the signal recorded during this test.

6.2.2 Signal Analysis

Just a reminder for those that jump in this document directly here: matrices M1 to M8 are on the blue array, and matrices M9 and M10 are on the red array.

The complete sequence: If you have RD1 in mind you remember that the readout circuit is multiplexed, therefore, as we are only checking the electrical continuity of the system here, I only plot one pixel per channel, i.e. pixels (i, i) on each meatrix. In the figures each timeline is displaced from the previous one for clarity. The signals are plotted in raw values. First because it does not really make sense to convert them here, and second because it allows for a check that the three readout modes (**Sbolo_only**, **Sref_only** and **Sbolo−Sref**) are correctly understood (the first two are unsigned 16-bits integers with a 0 V level around 16000, and the last one is in signed 16-bits integers with a 0 V

Table 17: Bias commanding checks for the last set of biases. A checkmark in the status column indicates that the command is correctly executed. For the BU biases, I indicate both the commanded value and that value corrected by the GND-BU level in parenthesis. Units in the table are Volts. This table contains the values observed on group 1 but all the other groups show the same behavior except for VDL-BU which is only slightly discrepant for group 1.

31/10/2006			
Bias name	Commanded values	Group 1	
		Value	Status
VGL-BU	2.6 (3.06)	3.06	√
VDL-BU	4.2 (4.66)	4.68	?
VSS-BU	1.5 (1.96)	1.95	√
VGL	3.0	3.00	√
VDL	3.0	3.00	√
VSS	1.3	1.30	√
VSMS-L	3.0	3.00	√
VINJ	3.0	3.00	√

level at 0). Figure 15 shows the 16 independant channels for each of the 10 matrices.

Since we are now looking for the first time at a test performed at 4 K and given that we have introduced some differences with respect to the test described in RD1, it is worth spending some time describing the signal patterns we observe.

Before the test begins, we have a short period of time with no data followed by a strong peak in the signal that indicates the switch on and biasing of the detectors. The first 4 downward steps that follow correspond to the VDD sequence. This is known to show a strong relaxation pattern that is very visible at 4 K. The following 3 upward steps correspond to the VH_BLIND scale. These are always much cleaner as we observe. In this "CUS-like" test, these two sequences are followed by a complex event corresponding to the preparation of the VRL scale that ends up with the setting of VH_BLIND before the VRL scale. This complex event is simply due to the introduction of artificial delays between each bias setting. At this location of the test we have 13 biases to set so it takes some time. In previous test this event was "condensed" in a single spike. The VRL scale is the symetric 5-steps sequence. Then we have a long plateau during which the group-per-group VRL scale occurs. This plateau ends with another complex event that signals the preparation of the VH-VL sequence (6 biases to set). This 4 steps VH-VL sequence follows, now clearly visible since we are at 4 K, and the test ends by the sequence of readout modes **Sbolo_only**, **Sref_only** and **Sbolo−Sref**.

Taking into account the differences between the test script used here and that of RD1, we can state that the signal behaves exactly as expected. Therefore regarding the signal behavior, **the functional test of 31/10/06 is a success**. With respect to the CUS-driven test that occured in the meantime, it is worth mentioning that **we do not see here the very strong drifts that affected matrix 10 at 300 K**. We have no good explanation for this.

Figure 15: Signal timeline for the 16 channels of matrices M1 and M2. Note that each timeline is artificially offset from the previous one for clarity. The first 4 downward steps correspond to the VDD sequence. The following 3 upward steps correspond to the VH_BLIND scale. In this "CUS-like" test, they are followed by a complex event corresponding to the preparation of the VRL scale that ends up with the setting of VH_BLIND before the VRL scale. This VRL scale is the symetric 5-steps sequence. Then we have a long plateau during which the group-per-group VRL scale occurs. This plateau ends with a rather complex event that signals the preparation of the VH-VL sequence. This 4 steps VH-VL sequence follows, now clearly visible since we are at 4 K, and the test ends by the sequence of readout modes **Sbolo_only**, **Sref_only** and **Sbolo−Sref**. We observe a behavior similar to the reference sequence of RD1: the signal in **Sbolo_only** is lower that in **Sref_only**.

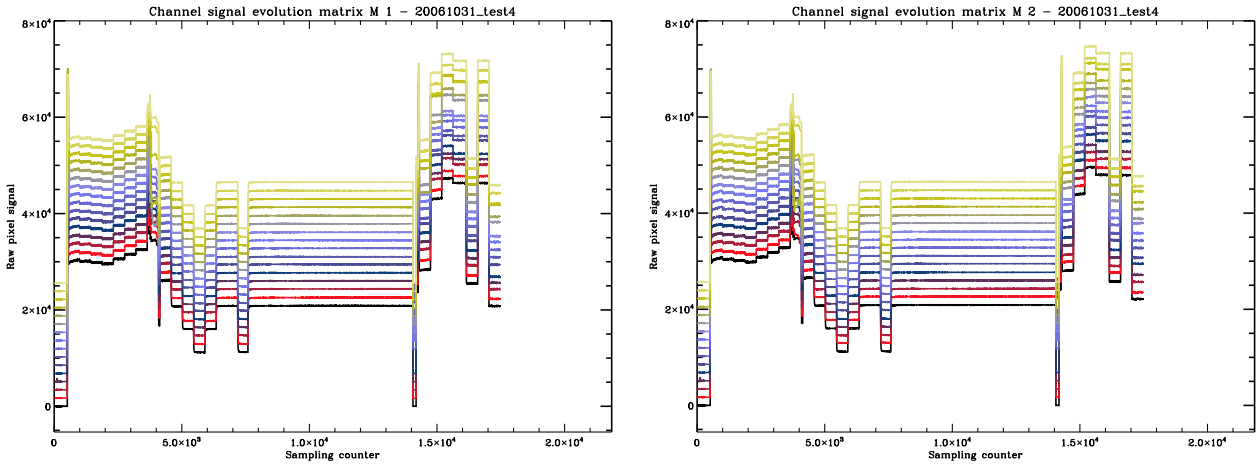

Channel signal evolution matrix M 1 – 20061031_test4
Channel signal evolution matrix M 2 – 20061031_test4
Raw pixel signal
Sampling counter

Figure 15: Continued. Signal timeline for the 16 channels of matrices M3 and M4.

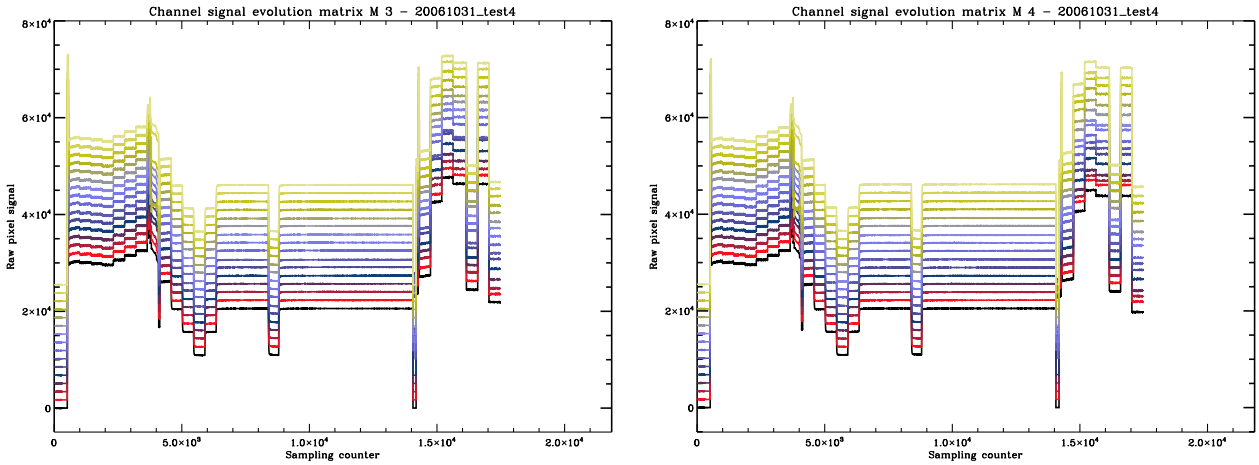

Channel signal evolution matrix M 3 – 20061031_test4
Channel signal evolution matrix M 4 – 20061031_test4
Raw pixel signal
Sampling counter

Figure 15: Continued. Signal timeline for the 16 channels of matrices M5 and M6.

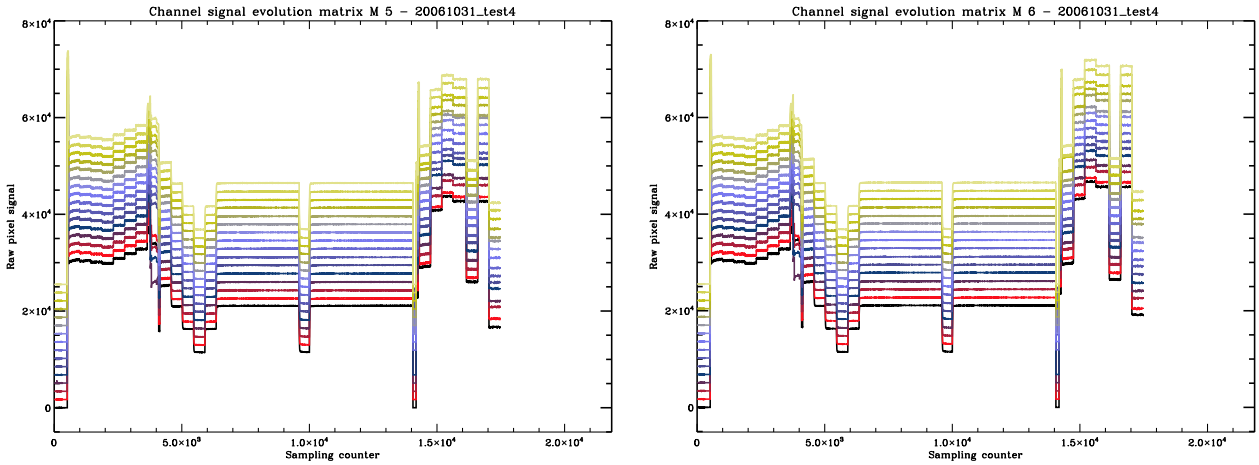

Channel signal evolution matrix M 5 – 20061031_test4
Channel signal evolution matrix M 6 – 20061031_test4
Raw pixel signal
Sampling counter

Figure 15: Continued. Signal timeline for the 16 channels of matrices M7 and M8.

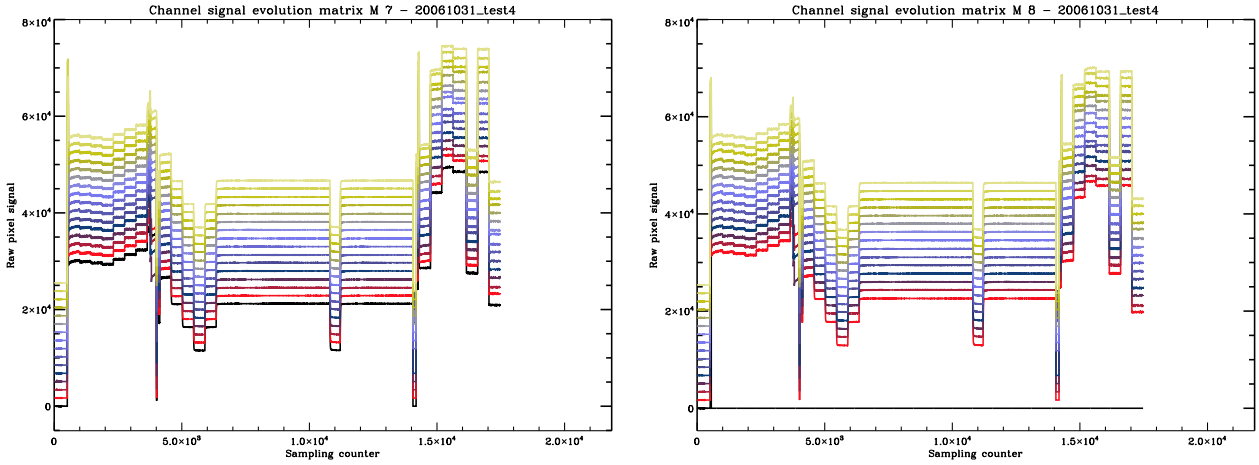
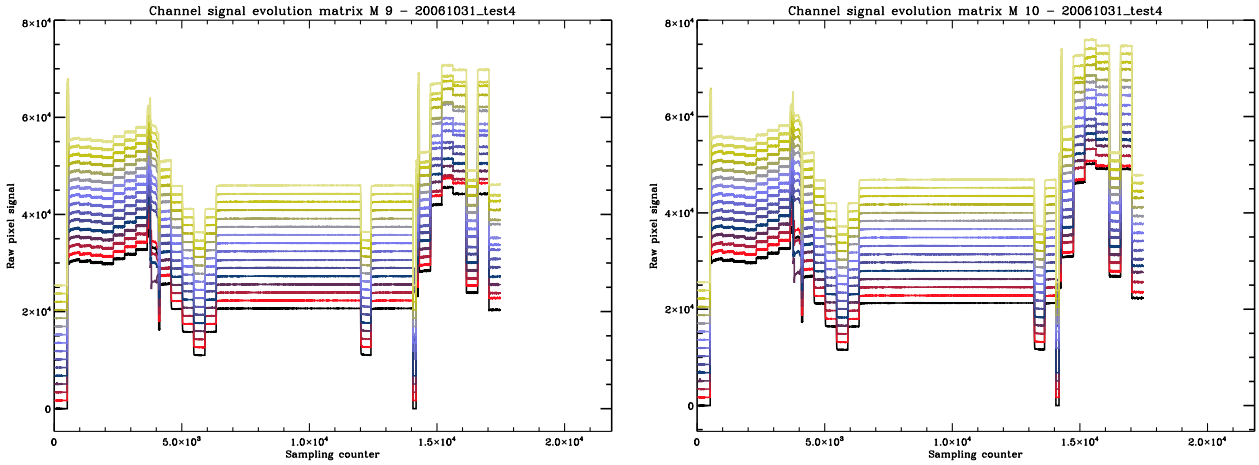

Channel signal evolution matrix M 7 – 20061031_test4
Channel signal evolution matrix M 8 – 20061031_test4
Raw pixel signal
Sampling counter

Figure 15: Continued. Signal timeline for the 16 channels of matrices M9 and M10.


Channel signal evolution matrix M 9 – 20061031_test4
Raw pixel signal
Sampling counter
Channel signal evolution matrix M 10 – 20061031_test4
Raw pixel signal
Sampling counter

The VH-VL sequence: In previous, warm, tests I needed to devote a section to this sequence as it was invisible on the pixel signal and I had to use the mean signal per matrix. This is no longer needed here in principle as the sequence is fully visible on figure 15. It is even more so in the mean signal that is so clean that it looks artificial.

Noise properties: In previous tests I have used the VH-VL sequence to comment on the noise properties of each matrix and correlation coefficients between the different matrices. As this still has some interest, I shall explore this now. Rather than using the mean of the full matrix, which is too clean a signal, it shall use the mean of the central 4×4 pixels area. Because the changes of VH and VL create such drastic changes of the signal level, a fourier analysis of the noise has to be restricted to a constant (VH, VL) set. I have chosen the section where VH is 0 V and VL is −0.15 V, because it is far away from the start of the sequence while still creating a polarization on the bolometer bridge. This is important because the start of the sequence creates a strong transient effect that is seen on all arrays. Finally when doing this analysis, one has to remember that the gain is set to high at the start of the sequence (while it was low for the rest of the test). This means with BOLC FM a gain of 5 μV/ADU

The noise power spectrum is very clean, as figure 16 shows. We have no spurious spike in the spectrum. However we see two things. First we still have a rather strong component at low frequency. This is due to the transient effect on the signal. Second the noise level is different from what we had at 300 K. It is now around 1-2 10^{-5} V.Hz$^{-1/2}$. This is quite higher than what we observed at 300 K. But this is not a real problem: at 300 K we were not picking up noise from the bolometer bridge, but rather from the electronics. At 4 K the bolometer bridge starts to be reactive, as revealed by the fact that we see dead pixels at that temperature. Hence we are starting to pick up its contribution to the noise. Since we are far from the operating conditions the fact that it is quite high is no cause for alarm. Finally on the noise issue, matrix 6 is no longer noisier that the other matrices.

Regarding the correlation between signals observed on different matrices, I first measure that all signals are strongly correlated (correlation coefficients of 0.65 and greater) whatever the pair of matrices used. However this is strictly due to the strong transient that affect all matrices. If I subtract from each signal its median filtered version (using a large median window, e.g. 21 readouts) I see that the resulting signals are completely uncorrelated, even for two matrices of the same group

6.3 Conclusions

Inspection of this test show that is was performed successfully, be it from the commanding side or from the signal side. We can therefore consider that it constitutes the reference LTU-driven 4 K level test, and that the LTU can now be safely put back in its box.

The explanation for the strong drifts observed with the CUS-driven 300 K level test has however not been found.

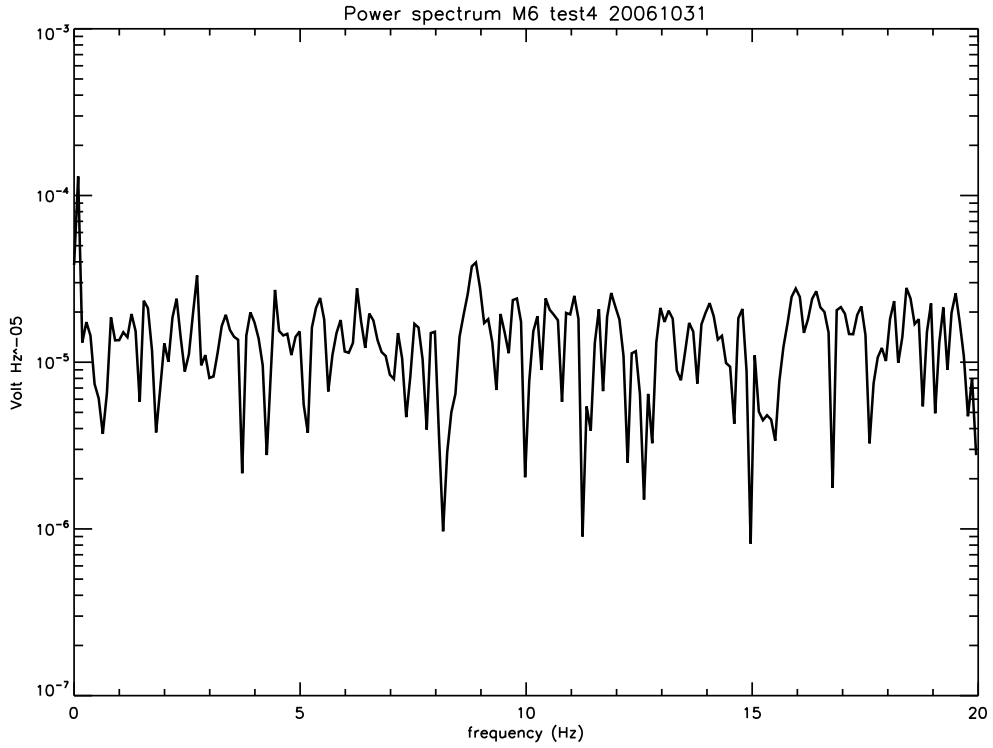


Figure 16: The power spectrum of the mean signal on the central 4×4 pixels area of matrix M6 observed during the third part of the `VH-VL` sequence (`VH` = 0.0, `VL` = −0.15) V of test #4. We see a strong low-frequency component corresponding to the long-term transient seen in the signal. Otherwise the noise level is quite homogenous, although higher than observed during the 300 K tests.

A The test scripts

Only the test part of the actual executed script is shown, i.e. switch-on and switch-off sequences are ommitted.

A.1 Test script of 17/07/2006

Note that the conversion tables use to go from analog to digital (both the decimal and the hexadecimal codes) are the FM tables. This is a mistake for the test in question that used BOLC QM1.

```
! ---------------------------------------------
! Reset bias all groups
# P 00 00 00 00
! Set seq mode Sref only
# P 09 01 00 01
! Set data mode Bolo & HK
# P 09 02 00 01
! Valider enregistrement TM
# S 09
! Set all groups bol bias 22 (VDD-PROT-BU) ON (1)
# P 00 16 0001
! Set all groups bol bias 21 (VDD-PROT-CL) ON (1)
# P 00 15 0001
! Set all groups bol bias 23 (GND-BU) ON (1)
# P 00 17 0001
! Set all groups bol bias 05 (VCH) to 0.00000000 Volt (0)
# P 00 05 0000
! Set all groups bol bias 19 (VGL-BU) to 3.00000000 Volt (2455)
# P 00 13 0997
! Set all groups bol bias 18 (VDL-BU) to 4.20000000 Volt (3436)
# P 00 12 0D6C
! Set all groups bol bias 17 (VSS-BU) to 1.00000000 Volt (819)
# P 00 11 0333
& ---------------------------------------------
& &
& debut test du BU
& &
& ---------------------------------------------
! Set all groups bol bias 15 (VGG) to 0.00000000 Volt (1)
# P 00 0F 0001
! Set gain low
# P 08 00 00 01
! Set all groups bol bias 20 (VH_BLIND) to 0.70026000 Volt (575)
# P 00 14 023F
! Set all groups bol bias 16 (VDD) to 1.20000000 Volt (981)
# P 00 10 03D5
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 16 (VDD) to 1.22000000 Volt (998)
# P 00 10 03E6
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 16 (VDD) to 1.24000000 Volt (1014)
# P 00 10 03F6
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 16 (VDD) to 1.26000000 Volt (1030)
# P 00 10 0406
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 20 (VH_BLIND) to 0.72000000 Volt (591)
# P 00 14 024F
! Attendre 5000 ms
```

```
# S 01 001388
! Set all groups bol bias 20 (VH_BLIND) to 0.74000000 Volt (608)
# P 00 14 0260
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 20 (VH_BLIND) to 0.76000000 Volt (624)
# P 00 14 0270
! Attendre 5000 ms
# S 01 001388
& ------------------------------------------------
& fin de test du BU
& blocage PEL commut
& &
& ------------------------------------------------
! Set all groups bol bias 15 (VGG) to 1.90000000 Volt (1556)
# P 00 0F 0614
! Set all groups bol bias 16 (VDD) to 2.60000000 Volt (2126)
# P 00 10 084E
! Set all groups bol bias 08 (VGL) to 3.00000000 Volt (3448)
# P 00 08 0D78
! Set all groups bol bias 06 (VDL) to 3.00000000 Volt (3447)
# P 00 06 0D77
! Set all groups bol bias 07 (VSS) to 0.70000000 Volt (804)
# P 00 07 0324
& ------------------------------------------------
& &
& Test du vrl
& &
& ------------------------------------------------
! Set all groups bol bias 11 (VDECX-H) to 0.00000000 Volt (0)
# P 00 0B 0000
! Set all groups bol bias 12 (VDECX-L) to 0.00000000 Volt (0)
# P 00 0C 0000
! Set all groups bol bias 09 (CKRLH) to 1.50000000 Volt (1724)
# P 00 09 06BC
! Set all groups bol bias 10 (CKRLL) to 1.50000000 Volt (1724)
# P 00 0A 06BC
! Set all groups bol bias 14 (VSMS-L) to 3.00000000 Volt (3447)
# P 00 0E 0D77
! Set all groups bol bias 13 (VSMS-H) to 0.00000000 Volt (0)
# P 00 0D 0000
! Set all groups bol bias 15 (VGG) to 1.80000000 Volt (1474)
# P 00 0F 05C2
& ------------------------------------------------
& &
& Courant de CL entre 0.5 uA et 2 uA
& &
& ------------------------------------------------
! Set all groups bol bias 20 (VH_BLIND) to 1.30000000 Volt (1067)
# P 00 14 042B
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 03 (VRL) to 0.30000000 Volt (345)
# P 00 03 0159
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 03 (VRL) to 0.40000000 Volt (459)
# P 00 03 01CB
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 03 (VRL) to 0.50000000 Volt (574)
# P 00 03 023E
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 03 (VRL) to 0.40000000 Volt (459)
# P 00 03 01CB
! Attendre 5000 ms
# S 01 001388
```

```
! Set all groups bol bias 03 (VRL) to 0.30000000 Volt (345)
# P 00 03 0159
! Attendre 5000 ms
# S 01 001388
& fin de test de VRL
! Set all groups bol bias 09 (CKRLH) to 0.00000000 Volt (0)
# P 00 09 0000
! Set all groups bol bias 10 (CKRLL) to 0.00000000 Volt (0)
# P 00 0A 0000
! Set all groups bol bias 11 (VDECX-H) to 2.00000000 Volt (2298)
# P 00 0B 08FA
! Set all groups bol bias 12 (VDECX-L) to 2.00000000 Volt (2298)
# P 00 0C 08FA
! Set all groups bol bias 04 (VINJ) to 3.00000000 Volt (3447)
# P 00 04 0D77
! Set all groups bol bias 20 (VH_BLIND) to 1.10000000 Volt (903)
# P 00 14 0387
! Set all groups bol bias 01 (VH) to 0.10000000 Volt (115)
# P 00 01 0073
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 02 (VL) to -0.10000000 Volt (277)
# P 00 02 0115
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 01 (VH) to 0.00000000 Volt (0)
# P 00 01 0000
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 02 (VL) to 0.00000000 Volt (0)
# P 00 02 0000
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 12 (VDECX-L) to 0.00000000 Volt (0)
# P 00 0C 0000
! Set all groups bol bias 09 (CKRLH) to 2.00000000 Volt (2298)
# P 00 09 08FA
! Set seq mode Sb only
# P 09 01 00 02
! Attendre 5000 ms
# S 01 001388
! Set seq mode Sref only
# P 09 01 00 01
! Attendre 5000 ms
# S 01 001388
! Set seq mode Sb-Sref
# P 09 01 00 00
! Attendre 5000 ms
# S 01 001388
! Inhiber enregistrement TM
# S 08
```

A.2 Test script of 24/08/2006

The script used was identical to that of 17/07/2006.

A.3 Test script of 11/10/2006

Comparing this script to the previous ones reveals subtle differences: First the VH_BLIND values are now those of RD1 as we have executed this test with the FM hardware. Second, we have introduced wait times after the switch on of the protection biases and of GND-BU. Draft 7 of RD1 elaborates on

these wait times.

```
! Reset bias all groups
# P 00 00 00 00
! Set all groups bol bias 22 (VDD-PROT-BU) ON (1)
# P 00 16 0001
! Attendre 1000 ms
# S 01 0003E8
! Set all groups bol bias 21 (VDD-PROT-CL) ON (1)
# P 00 15 0001
! Attendre 1000 ms
# S 01 0003E8
! Set all groups bol bias 23 (GND-BU) ON (1)
# P 00 17 0001
! Attendre 1000 ms (17.00)
# S 01 0003E8
! Set all groups bol bias 05 (VCH) to 0.00000000 Volt (0)
# P 00 05 0000
! Set all groups bol bias 19 (VGL-BU) to 3.00000000 Volt (2455)
# P 00 13 0997
! Set all groups bol bias 18 (VDL-BU) to 4.20000000 Volt (3436)
# P 00 12 0D6C
! Set all groups bol bias 17 (VSS-BU) to 1.00000000 Volt (819)
# P 00 11 0333
& ---
& debut test du BU
& ---
! Set seq mode Sref only
& ---
# P 09 01 00 01
! Set data mode Bolo & HK
# P 09 02 00 01
! Set all groups bol bias 15 (VGG) to 0.00000000 Volt (1)
# P 00 0F 0001
! Set gain low
# P 08 00 00 01
! Set all groups bol bias 20 (VH_BLIND) to 1.20000000 Volt (982)
# P 00 14 03D6
! Set all groups bol bias 16 (VDD) to 1.20000000 Volt (981)
# P 00 10 03D5
& vout autour de 30000 pas codeur
! Valider enregistrement TM
# S 09
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 16 (VDD) to 1.22000000 Volt (998)
# P 00 10 03E6
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 16 (VDD) to 1.24000000 Volt (1014)
# P 00 10 03F6
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 16 (VDD) to 1.26000000 Volt (1030)
# P 00 10 0406
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 20 (VH_BLIND) to 1.22000000 Volt (998)
# P 00 14 03E6
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 20 (VH_BLIND) to 1.24000000 Volt (1014)
# P 00 14 03F6
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 20 (VH_BLIND) to 1.26000000 Volt (1031)
# P 00 14 0407
```

```
! Attendre 5000 ms
# S 01 001388
& ----
& fin de test du BU
& ----
& blocage PEL commut
& ----
! Set all groups bol bias 15 (VGG) to 1.90000000 Volt (1556)
# P 00 0F 0614
! Set all groups bol bias 16 (VDD) to 2.60000000 Volt (2126)
# P 00 10 084E
! Set all groups bol bias 08 (VGL) to 3.00000000 Volt (3448)
# P 00 08 0D78
! Set all groups bol bias 06 (VDL) to 3.00000000 Volt (3447)
# P 00 06 0D77
! Set all groups bol bias 07 (VSS) to 0.70000000 Volt (804)
# P 00 07 0324
& ---
& test du vrl
& ---
! Set all groups bol bias 11 (VDECX-H) to 0.00000000 Volt (0)
# P 00 0B 0000
! Set all groups bol bias 12 (VDECX-L) to 0.00000000 Volt (0)
# P 00 0C 0000
! Set all groups bol bias 09 (CKRLH) to 1.50000000 Volt (1724)
# P 00 09 06BC
! Set all groups bol bias 10 (CKRLL) to 1.50000000 Volt (1724)
# P 00 0A 06BC
! Set all groups bol bias 14 (VSMS-L) to 3.00000000 Volt (3447)
# P 00 0E 0D77
! Set all groups bol bias 13 (VSMS-H) to 0.00000000 Volt (0)
# P 00 0D 0000
! Set all groups bol bias 15 (VGG) to 1.80000000 Volt (1474)
# P 00 0F 05C2
& ---
& Courant de CL entre 0.5 uA et 2 uA
& ---
! Set all groups bol bias 20 (VH_BLIND) to 1.80000000 Volt
# P 00 14 05C1
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 03 (VRL) to 0.30000000 Volt (345)
# P 00 03 0159
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 03 (VRL) to 0.40000000 Volt (459)
# P 00 03 01CB
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 03 (VRL) to 0.50000000 Volt (574)
# P 00 03 023E
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 03 (VRL) to 0.40000000 Volt (459)
# P 00 03 01CB
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 03 (VRL) to 0.30000000 Volt (345)
# P 00 03 0159
! Attendre 5000 ms
# S 01 001388
& fin de test de VRL
! Set all groups bol bias 09 (CKRLH) to 0.00000000 Volt (0)
# P 00 09 0000
! Set all groups bol bias 10 (CKRLL) to 0.00000000 Volt (0)
# P 00 0A 0000
! Set all groups bol bias 11 (VDECX-H) to 2.00000000 Volt (2298)
# P 00 0B 08FA
```

```
! Set all groups bol bias 12 (VDECX-L) to 2.00000000 Volt (2298)
# P 00 0C 08FA
! Set all groups bol bias 04 (VINJ) to 3.00000000 Volt (3447)
# P 00 04 0D77
! Set all groups bol bias 20 (VH_BLIND) to 1.15000000 Volt (941)
# P 00 14 03AD
! Set gain high
# P 08 00 00 00
! Set all groups bol bias 01 (VH) to 0.10000000 Volt (115)
# P 00 01 0073
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 02 (VL) to -0.10000000 Volt (277)
# P 00 02 0115
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 01 (VH) to 0.00000000 Volt (0)
# P 00 01 0000
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 02 (VL) to 0.00000000 Volt (0)
# P 00 02 0000
! Attendre 5000 ms
# S 01 001388
! Set all groups bol bias 12 (VDECX-L) to 0.00000000 Volt (0)
# P 00 0C 0000
! Set all groups bol bias 09 (CKRLH) to 2.00000000 Volt (2298)
# P 00 09 08FA
! Set seq mode Sb only
# P 09 01 00 02
! Attendre 5000 ms
# S 01 001388
! Set seq mode Sref only
# P 09 01 00 01
! Attendre 5000 ms
# S 01 001388
! Set seq mode Sb-Sref
# P 09 01 00 00
! Attendre 5000 ms
# S 01 001388
! Inhiber enregistrement TM
# S 08
Fin Batch
```

A.4 Test script of 31/10/2006

This test script corresponds to the 4 K level test. There are some bias differences with the test scripts corresponding to the 300 K level. Also when comparing it to the previous test script or to the test script of RD1, you will see that we have introduced artificial wait times to mimic the incompressible rate of two commands per second introduced by the CUS.

```
/
/  Batch de test  4K
/  Driv du test  300K tel que effectu a garching le 11/10/06
/  avec ajout de 0.5s avec chaque TC pour simuler SCOS2000
/ ------------------------------------------
/
/ Tests fonctionnels  4K
/
/ ------------------------------------------
/ Valider enregistrement TM
```

```
# S 09
/ Attendre 1000 ms
# S 01 0003E8
/ Set data mode Bolo & HK
# P 09 02 00 01
/ Attendre 1000 ms
# S 01 0003E8
/ Reset bias all groups
# P 00 00 00 00
/ Set all groups bol bias 22 (VDD-PROT-BU) ON (1)
# P 00 16 0001
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 21 (VDD-PROT-CL) ON (1)
# P 00 15 0001
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 23 (GND-BU) ON (1)
# P 00 17 0001
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 05 (VCH) to 0.00000000 Volt (0)
# P 00 05 0000
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 19 (VGL-BU) to 2.60000000 Volt (2125)
# P 00 13 084D
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 18 (VDL-BU) to 4.20000000 Volt (3435)
# P 00 12 0D6B
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 17 (VSS-BU) to 1.50000000 Volt (1227)
# P 00 11 04CB
/ Attendre 1000 ms
# S 01 0003E8
& ---
& debut test du BU
& ---
/ Set seq mode Sref only
# P 09 01 00 01
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 15 (VGG) to 0.00000000 Volt (1)
# P 00 0F 0001
/ Attendre 1000 ms
# S 01 0003E8
/ Set gain low
# P 08 00 00 01
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 20 (VH_BLIND) to 1.50000000 Volt (1227)
# P 00 14 04CB
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 16 (VDD) to 1.40050000 Volt (1146)
# P 00 10 047A
/ Attendre 1000 ms
# S 01 0003E8
& ----
& vaut autour de 30000 pas codeur
& ----
/ Attendre 10000 ms
# S 01 002710
/ Set all groups bol bias 16 (VDD) to 1.42000000 Volt (1162)
# P 00 10 048A
/ Attendre 1000 ms
```

```
# S 01 0003E8
/ Attendre 10000 ms
# S 01 002710
/ Set all groups bol bias 16 (VDD) to 1.44000000 Volt (1178)
# P 00 10 049A
/ Attendre 1000 ms
# S 01 0003E8
/ Attendre 10000 ms
# S 01 002710
/ Set all groups bol bias 16 (VDD) to 1.46000000 Volt (1195)
# P 00 10 04AB
/ Attendre 1000 ms
# S 01 0003E8
/ Attendre 10000 ms
# S 01 002710
/ Set all groups bol bias 20 (VH_BLIND) to 1.52000000 Volt (1244)
# P 00 14 04DC
/ Attendre 1000 ms
# S 01 0003E8
/ Attendre 10000 ms
# S 01 002710
/ Set all groups bol bias 20 (VH_BLIND) to 1.54000000 Volt (1260)
# P 00 14 04EC
/ Attendre 1000 ms
# S 01 0003E8
/ Attendre 10000 ms
# S 01 002710
/ Set all groups bol bias 20 (VH_BLIND) to 1.56000000 Volt (1276)
# P 00 14 04FC
/ Attendre 1000 ms
# S 01 0003E8
/ Attendre 10000 ms
# S 01 002710
& ----
& fin de test du BU
& ----
& blocage PEL commut
& ----
/ Set all groups bol bias 15 (VGG) to 1.30000000 Volt (1064)
# P 00 0F 0428
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 16 (VDD) to 2.60000000 Volt (2128)
# P 00 10 0850
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 08 (VGL) to 3.00000000 Volt (3447)
# P 00 08 0D77
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 06 (VDL) to 3.00000000 Volt (3447)
# P 00 06 0D77
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 07 (VSS) to 1.30000000 Volt (1494)
# P 00 07 05D6
/ Attendre 1000 ms
# S 01 0003E8
& ---
& test du vrl
& ---
/ Set all groups bol bias 11 (VDECX-H) to 0.00000000 Volt (0)
# P 00 0B 0000
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 12 (VDECX-L) to 0.00000000 Volt (0)
# P 00 0C 0000
/ Attendre 1000 ms
```

```
# S 01 0003E8
/ Set all groups bol bias 09 (CKRLH) to 1.50000000 Volt (1724)
# P 00 09 06BC
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 10 (CKRLL) to 1.50000000 Volt (1724)
# P 00 0A 06BC
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 14 (VSMS-L) to 3.00000000 Volt (3447)
# P 00 0E 0D77
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 13 (VSMS-H) to 0.00000000 Volt (0)
# P 00 0D 0000
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 15 (VGG) to 1.15000000 Volt (941)
# P 00 0F 03AD
/ Attendre 1000 ms
# S 01 0003E8
& ---
& Courant de CL entre 100 et 300 nA
& ---
/ Set all groups bol bias 20 (VH_BLIND) to 1.75000000 Volt (1432)
# P 00 14 0598
/ Attendre 1000 ms
# S 01 0003E8
/ Attendre 10000 ms
# S 01 002710
/ Set all groups bol bias 03 (VRL) to 0.20000000 Volt (230)
# P 00 03 00E6
/ Attendre 1000 ms
# S 01 0003E8
/ Attendre 10000 ms
# S 01 002710
/ Set all groups bol bias 03 (VRL) to 0.30000000 Volt (345)
# P 00 03 0159
/ Attendre 1000 ms
# S 01 0003E8
/ Attendre 10000 ms
# S 01 002710
/ Set all groups bol bias 03 (VRL) to 0.40000000 Volt (460)
# P 00 03 01CC
/ Attendre 1000 ms
# S 01 0003E8
/ Attendre 10000 ms
# S 01 002710
/ Set all groups bol bias 03 (VRL) to 0.30000000 Volt (345)
# P 00 03 0159
/ Attendre 1000 ms
# S 01 0003E8
/ Attendre 10000 ms
# S 01 002710
/ Set all groups bol bias 03 (VRL) to 0.20000000 Volt (230)
# P 00 03 00E6
/ Attendre 1000 ms
# S 01 0003E8
/ Attendre 10000 ms
# S 01 002710
& ---
& fin de test de VRL
& ---
& ---
& test de VRL pour chaque groupe
& ---
& ---
& groupe 1
```

```
& ---
/ Set group 1 bol bias 03 (VRL) to 0.20000000 Volt (230)
# P 01 03 00E6
/ Attendre 10000 ms
# S 01 002710
/ Set group 1 bol bias 03 (VRL) to 0.40000000 Volt (460)
# P 01 03 01CC
/ Attendre 10000 ms
# S 01 002710
/ Set group 1 bol bias 03 (VRL) to 0.20000000 Volt (230)
# P 01 03 00E6
/ Attendre 10000 ms
# S 01 002710
& ---
& groupe 2
& ---
/ Set group 2 bol bias 03 (VRL) to 0.20000000 Volt (230)
# P 02 03 00E6
/ Attendre 10000 ms
# S 01 002710
/ Set group 2 bol bias 03 (VRL) to 0.40000000 Volt (460)
# P 02 03 01CC
/ Attendre 10000 ms
# S 01 002710
/ Set group 2 bol bias 03 (VRL) to 0.20000000 Volt (230)
# P 02 03 00E6
/ Attendre 10000 ms
# S 01 002710
& ---
& groupe 3
& ---
/ Set group 3 bol bias 03 (VRL) to 0.20000000 Volt (230)
# P 03 03 00E6
/ Attendre 10000 ms
# S 01 002710
/ Set group 3 bol bias 03 (VRL) to 0.40000000 Volt (460)
# P 03 03 01CC
/ Attendre 10000 ms
# S 01 002710
/ Set group 3 bol bias 03 (VRL) to 0.20000000 Volt (230)
# P 03 03 00E6
/ Attendre 10000 ms
# S 01 002710
& ---
& groupe 4
& ---
/ Set group 4 bol bias 03 (VRL) to 0.20000000 Volt (230)
# P 04 03 00E6
/ Attendre 10000 ms
# S 01 002710
/ Set group 4 bol bias 03 (VRL) to 0.40000000 Volt (460)
# P 04 03 01CC
/ Attendre 10000 ms
# S 01 002710
/ Set group 4 bol bias 03 (VRL) to 0.20000000 Volt (230)
# P 04 03 00E6
/ Attendre 10000 ms
# S 01 002710
& ---
& groupe 5
& ---
/ Set group 5 bol bias 03 (VRL) to 0.20000000 Volt (230)
# P 05 03 00E6
/ Attendre 10000 ms
# S 01 002710
/ Set group 5 bol bias 03 (VRL) to 0.40000000 Volt (460)
# P 05 03 01CC
/ Attendre 10000 ms
```

```
# S 01 002710
/ Set group 5 bol bias 03 (VRL) to 0.20000000 Volt (230)
# P 05 03 00E6
/ Attendre 10000 ms
# S 01 002710
& ---
& groupe 6
& ---
/ Set group 6 bol bias 03 (VRL) to 0.20000000 Volt (230)
# P 06 03 00E6
/ Attendre 10000 ms
# S 01 002710
/ Set group 6 bol bias 03 (VRL) to 0.40000000 Volt (460)
# P 06 03 01CC
/ Attendre 10000 ms
# S 01 002710
/ Set group 6 bol bias 03 (VRL) to 0.20000000 Volt (230)
# P 06 03 00E6
/ Attendre 10000 ms
# S 01 002710
& ---
& fin du test groupe par groupe
& ---
/ Set all groups bol bias 09 (CKRLH) to 0.00000000 Volt (0)
# P 00 09 0000
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 10 (CKRLL) to 0.00000000 Volt (0)
# P 00 0A 0000
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 11 (VDECX-H) to 2.00000000 Volt (2298)
# P 00 0B 08FA
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 12 (VDECX-L) to 2.00000000 Volt (2298)
# P 00 0C 08FA
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 04 (VINJ) to 3.00000000 Volt (3447)
# P 00 04 0D77
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 20 (VH_BLIND) to 1.70000000 Volt (1391)
# P 00 14 056F
/ Attendre 1000 ms
# S 01 0003E8
/ Set gain high
# P 08 00 00 00
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 01 (VH) to 0.50000000 Volt (575)
# P 00 01 023F
/ Attendre 1000 ms
# S 01 0003E8
/ Attendre 10000 ms
# S 01 002710
/ Set all groups bol bias 02 (VL) to -0.15000000 Volt (416)
# P 00 02 01A0
/ Attendre 1000 ms
# S 01 0003E8
/ Attendre 10000 ms
# S 01 002710
/ Set all groups bol bias 01 (VH) to 0.00000000 Volt (0)
# P 00 01 0000
/ Attendre 1000 ms
# S 01 0003E8
/ Attendre 10000 ms
```

```
# S 01 002710
/ Set all groups bol bias 02 (VL) to 0.00000000 Volt (0)
# P 00 02 0000
/ Attendre 1000 ms
# S 01 0003E8
/ Attendre 10000 ms
# S 01 002710
/ Set all groups bol bias 12 (VDECX-L) to 0.00000000 Volt (0)
# P 00 0C 0000
/ Attendre 1000 ms
# S 01 0003E8
/ Set all groups bol bias 09 (CKRLH) to 2.00000000 Volt (2298)
# P 00 09 08FA
/ Attendre 1000 ms
# S 01 0003E8
/ Set seq mode Sb only
# P 09 01 00 02
/ Attendre 1000 ms
# S 01 0003E8
/ Attendre 10000 ms
# S 01 002710
/ Set seq mode Sref only
# P 09 01 00 01
/ Attendre 1000 ms
# S 01 0003E8
/ Attendre 10000 ms
# S 01 002710
/ Set seq mode Sb-Sref
# P 09 01 00 00
/ Attendre 1000 ms
# S 01 0003E8
/ Attendre 10000 ms
# S 01 002710
/ Inhiber enregistrement TM
# S 08
```